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Lesson 12: Feeding Dairy Cows to Reduce Nutrient Excretion -Rick Grant and Stanley (Lee) Telega

Intended Outcomes
The participants will

- Understand the impact of dietary nutrient content on nitrogen (N), phosphorus (P), and potassium (K) excretion by dairy cows.
- Understand the basic idea of nutrient balance on dairy farms.
- Learn what the recommended requirements are of N, P, and K for dairy cows to avoid overfeeding these nutrients.
- Learn feeding practices that will maximize animal performance and minimize nutrient excretion.
- Understand the land requirements needed to manage the manure nutrients on dairy farms.

Contents

Activities
The participants will

- Calculate the amount of N, P, and K excreted by cows in their herd.
- Conduct a self-assessment of how well their herd minimizes nutrient excretion and evaluate approaches to improve their feeding program.
- Learn about several websites with useful information to help them calculate nutrient excretion by their herd, calculate land base needed for managing the manure, and to understand the consequences of overfeeding N, P, or K.

Reducing N, P, and K Excretion: the Challenge for Dairy Producers

Increasingly, our society demands livestock production systems that not only produce economic, high-quality food products but also minimize negative environmental impacts. Feeding management has improved continuously and helps to explain steadily increasing milk production. The future challenge for dairy producers and nutritionists will be to properly formulate rations for high production levels while simultaneously minimizing the environmental impact of excessive nitrogen (N), phosphorus (P), and potassium (K) excretion in the manure. A realistic approach will be to keep formulation of profitable, balanced rations as the primary goal but to also give substantial consideration to adjusting formulations and feeding strategy, minimizing any negative environmental impact.

In many cases, a properly formulated ration that precisely meets the cow's requirements for milk production, maintenance, and gestation will also minimize excessive N, P, and K excretion in the manure and urine. Increasingly, we have ration formulation software that allows us to accomplish this goal.

This lesson will present the basics of feeding dairy cows to minimize N, P, and K excretion into the environment. In addition, key concepts of managing manure nutrients on dairy operations are presented.

The next section provides an overview of the key concepts of nutrient balance on dairy operations. The goal is to understand the nutrient inputs, outputs, and consequently, the percentage of nutrients that remain on the farm or are lost into the environment.

A realistic approach will be to keep formulation of profitable, balanced rations as the primary goal but to also give substantial consideration to adjusting formulations and feeding strategy, minimizing any negative environmental impact.

Key Concepts of Nutrient Balance on a Dairy Farm

An assessment of nutrient balance on a dairy farm allows you to determine management options that increase nutrient recycling from cropland to the cattle and back to crops again (Klausner 1993). A more detailed discussion of whole farm nutrient balance can be found in Lesson 2, Whole Farm Nutrient Planning.

Nutrient management decisions must relate to the movement of nutrients onto the farm, movement of nutrients within the farm system (including all cropland owned and leased by the dairy), and movement of nutrients out of the farm system. Figure 12-1 illustrates a simplified flow of nutrients on a typical dairy farm. Usually, N, P, K, and other nutrients are brought into the farm system via purchased feeds and fertilizer, although N also enters the farm via N fixation by legumes and rainfall. These same nutrients leave the farm in products sold such as milk, meat, and crops. *The magnitude of any resulting losses is driven by the difference in inputs and outputs.*

Nutrients normally become concentrated on dairy farms because more are brought into the farm system than leave in the products sold. Table 12-1 illustrates the mass N and P balances for several dairy farms in New York as summarized by Klausner (1993).

Although the actual values for N and P inputs and outputs will vary, depending on the farm's location in the United States and the resources available, Table 12-1 does provide a good overview of the typical capture of nutrients on a dairy farm. For instance, notice that the percentage of N remaining on these farms ranged from 64% to 76% and was not related to the dairy's size. But, with greater herd size, more N (or P) must be managed and therefore more acres of cropland will be needed to effectively use the nutrients from the dairy. The mass balance for P is similar to N; in each case, a large percentage of the P that is brought onto the farm each year remains on the farm and accumulates over years. Although data are lacking, it is possible that microminerals (such as sodium and chloride) also accumulate.

Since nutrient accumulation is common on dairy operations, you need to develop a nutrient management plan that ensures efficient nutrient use by and minimal environmental impact from the cattle and crops. Keep in mind that these mass balances are only estimates of the actual nutrient status of a dairy. To develop a specific mass balance for your dairy, use the tools found in Lesson 2, Whole Farm Nutrient Planning.

Follow the steps below to minimize the flow of N, P, K, and other nutrient inputs onto your farm:

1. Determine the actual nutrient requirements of the cattle and crops before making feed and fertilizer purchases.
2. Sample and analyze feeds during ration formulation; do not rely on "book values."
3. Use soil testing to determine crop requirements.

To reduce the amount of feed purchased on most dairies, maximize the harvest of high-quality forages. When more nutrients come from homegrown forages, then fewer nutrients must be purchased and brought onto the farm.

Remember that purchased feeds and fertilizers are a major route for nutrients to enter the farm. Each purchase must be scrutinized carefully to avoid unnecessary accumulation of nutrients on the dairy.

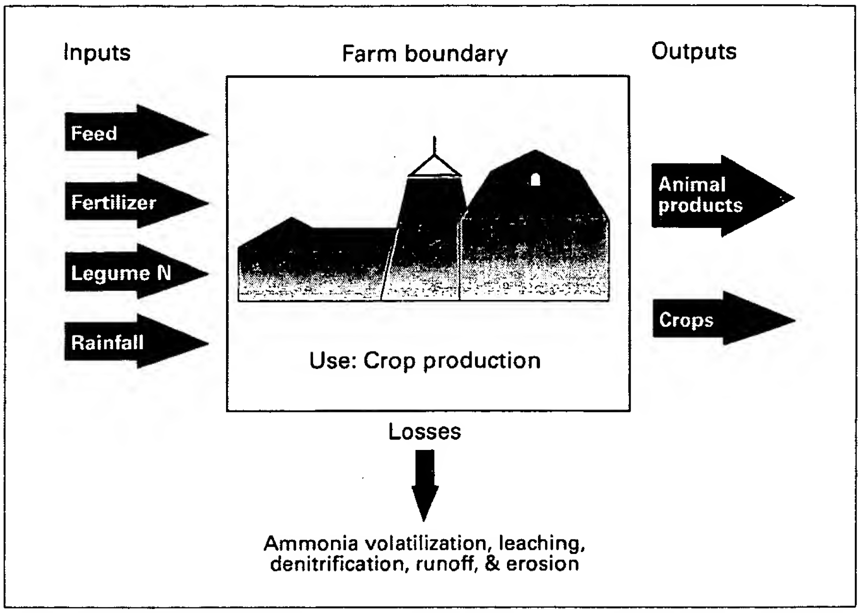

Figure 12-1. A simplified diagram of nutrient flow on a typical dairy operation.
Source: Klausner 1993.

Table 12-1. Mass N and P balances for New York dairy farms.

	Size of Dairy, Number of Cows		
	45	320	500
Input	------(tons of N per year)------		
Purchased fertilizer	1.0	13.5	26.1
Purchased feed	3.8	43.8	78.5
N fixation by legumes	1.3	14.6	13.9
Purchased cattle	0	0.1	0
Total inputs	*6.1*	*72.0*	*118.5*
Output			
Milk	2.0	18.6	26.4
Cattle sold	0.1	1.9	1.9
Crops sold	0.1	0	0
Total outputs	*2.2*	*20.5*	*28.3*
Remainder	3.9 (6.1-2.2)	51.5 (72-20.5)	90.2 (29.2-28.3)
% Remaining on farm	64%	71%	76%
Input	------(tons of P per year)------		
Purchased fertilizer	1.2	2.0	5.5
Purchased feed	1.0	8.4	14.2
Purchased cattle	0	0.03	0
Total inputs	*2.2*	*10.4*	*24.2*
Output			
Milk	0.36	3.8	5.5
Cattle sold	0.05	0.5	0.5
Crops sold	0.01	0	0
Total outputs	*0.43*	*4.3*	*6.0*
Remainder	1.8 (2.2-.43)	6.2 (10.4-4.3)	18.2 (24.2-6)
% Remaining on farm	81%	59%	75%

Adapted from Klausner 1993.

How Much N, P, and K Does a Dairy Cow Excrete?

When manure management systems are designed, standard excretion amounts for N, P, and K are often used. These values have been tabulated by the American Society of Agricultural Engineers (1990) and estimate the daily and yearly excretion of N, P, and K based on the cow's body weight and also provide reasonably good estimates of nutrient excretion. However, these standard values do not account for the large variation among dairy farms in feed intake levels, rations fed, feeding programs, and consequently, actual nutrient excretion levels.

Research conducted at the University of Florida in the early 1990s (Morse et al. 1992; Tomlinson 1992) showed that N and P excretion by dairy cows varies substantially with the amount and rumen degradability of N (crude protein, CP) and the P fed in the ration. In fact, these researchers concluded that the amount of N and P excreted daily can be reasonably predicted based on daily intake of N and P, dry matter intake, and milk production.

Table 12-2 shows the daily and yearly excretion of N, P, and K by 1,400-pound Holstein cows. Clearly, the amount of N, P, and K in the diet has a dramatic effect on the yearly excretion of these nutrients. For instance, increasing the amount of P from 0.40% to 0.60% of the ration dry matter increased excretion of P from 40 to 69 pounds/cow yearly. According to a 1998 survey of dairy nutritionists in Nebraska, this difference of almost 30 lbs in P excretion accurately reflects the actual range in P levels that are currently being fed in the dairy industry. Surveys in other states such as Texas, Florida, and Wisconsin confirm these observations (Morse 1989, Sansinena et al. 1999), although the degree of P oversupplementation may be less in western states (Meyer 2001). Even though the actual P requirement of high-producing dairy cows is near 0.40% of ration dry matter (NRC 2001), some U.S. farmers commonly feed in excess of 0.50%. Clearly, this is one feeding practice that can be modified to have a large impact on P excretion.

Clearly, the amount of N, P, and K in the diet has a dramatic effect on the yearly excretion of these nutrients.

Table 12-3 illustrates a straightforward method to calculate the amount of N, P, or K produced by a lactating herd of dairy cows based on nutrient intake and level of production. Although simplified, this approach allows you to obtain a reasonably accurate estimate of N and P excretion for planning purposes.

In the example provided in Table 12-3, you calculate the total N, P, and K excreted by a group of 100 high-producing dairy cows. Following are the steps needed to manually complete this worksheet for any group of cattle on your farm:

1. List the groups of cattle on your farm with the number of cattle in each group. In the example in Table 12-3, a group of 100 dairy cows is producing 90 pounds of milk per day.
2. Enter the daily feed intake (dry basis) for the entire group (5,500 lbs/d for the example).
3. Enter the crude protein (CP), N, P, and K content of the ration fed to this group in decimal form [0.175 (17.5%) CP, 0.028 (2.8%) N, 0.0040 (0.40%) P, and 0.015 (1.5%) K for the example].
4. Total the amount of N, P, and K consumed daily by this group of cattle by multiplying daily dry matter intake by nutrient content (154 lbs/d N, 22 lbs/d P, and 82.5 lbs/d K for the example).
5. If the group of cattle is gaining weight, then you can calculate the amount of N, P, and K that is retained in the body tissue of those cattle. To do this, multiply the number of cattle in the group x the average

Table 12-2. Daily and yearly excretion of N, P, and K by 1,400-pound Holstein dairy cow.

	ASAE[1] Standard	0-30 DIM[2]	31-100 DIM	101-305 DIM	60-day Dry Period	Yearly Total
Milk, pounds/cow		100	70	50	Dry	21,750 lbs
DMI[3], pounds/cow		55.8	46.3	39.2	25.2	14,462 lbs
Pounds N excreted/day						**lbs/cow/yr**
Total N (low protein degradability)	0.63	0.89	0.73	0.60	0.36	223
Total N (high protein degradability)	0.63	1.03	0.85	0.70	0.44	260
Pounds P excreted/day						**lbs/cow/yr**
0.40% P in diet	0.132	0.123	0.115	0.107	0.101	40
0.45% P in diet	0.132	0.151	0.138	0.136	0.103	46
0.60% P in diet	0.132	0.235	0.208	0.185	0.151	69
Pounds K excreted/day						**lbs/cow/yr**
0.80% K in diet	0.406	0.296	0.265	0.239	0.201	88
1.2% K in diet	0.406	0.519	0.450	0.396	0.302	146

Source: Van Horn 1992, page 640.
[1]American Society of Agricultural Engineers
[2]Days in milk
[3]Dry matter intake

daily gain x the content of N, P, and K in the tissue (provided in the table). In the example, because the high-producing cows are not gaining weight, there is no retention of N, P, or K. Most lactating dairy cows will begin to regain lost body weight by 70 to 84 days in milk.

6. Calculate the amount of N, P, and K secreted in the milk (45 lbs/d N, 9.0 lbs/d P, and 13.5 lbs/d K for the example).
7. Finally, calculate the total N, P, and K excretion by each group of cattle for a selected time period. In the example, the 100 cows are in the group for 100 days. The N, P, and K retained in tissue (0 in this example) plus the N, P, and K secreted in milk are subtracted from the total N, P, and K consumed. In the example, this results in excretion of 10,900 lbs N; 1,300 lbs P; and 6,900 lbs K over the time period of 100 days by these 100 lactating dairy cows.

A similar method for estimating dairy cow N, P, and K output, a spreadsheet developed at the University of Nebraska, is available at the following website: <*http://www.ianr.unl.edu/manure*>. This Excel® spreadsheet estimates the excretion of N, P, and K by dairy cows, the quantity of nutrients remaining after losses, and the land needs for using these nutrients at agronomic rates. To generate more accurate estimates of nutrient excretion than shown in Table 12-3 and develop a nutrient use plan, you will need to enter the following information into the spreadsheet:

- Number of cows
- Daily feed intake
- Dietary CP, P, and K
- Daily milk production
- Cow body weight

This user-friendly spreadsheet is based on data reported by University of Florida researchers (Van Horn 1992) and summarized in Table 12-2. The next section briefly describes the land requirements needed to manage manure nutrients on dairy operations and the impact of dietary N and P on the land base needed.

Land Requirements for Managing Manure Nutrients on Dairy Operations

If the owned or managed land available for manure application is inadequate for the agronomic application of manure, dairy producers must identify sufficient land to utilize N and P. The P-based management of manure requires much more land base than N-based management. Presently, land requirements are commonly regulated based on N, but growing pressure exists for greater regulation of P buildup in the soil. Many states are

Table 12-3. Total manure nutrients produced by dairy cattle based upon ration nutrients.

Feed Nutrient Intake

Animal Group	A. Daily Feed Intake, lbs	B. Feed Nutrient Concentration				C. Total Nutrient in Feed, lbs = A x B		
		Protein	N[1]	P	K	N	P	K
Example: 100 high-producing dairy cows	*5,500 lbs DM/d*	*0.175*	*0.175 ÷ 6.25 = 0.028*	*0.0040*	*0.015*	*5,500 x 0.028 = 154 lbs/d*	*5,500 x 0.0040 = 22 lbs/d*	*5,500 x 0.015 = 82.5 lbs/d*

Nutrients Retained by Animal (if cow is gaining weight) or Secreted in Milk

Animal Group	D. Number of Animals	E. Average Daily Gain	F. Live Weight Nutrient Concentration			G. Nutrients Retained by Animal, lbs = D x E x F		
			N	P	K	N	P	K
Example: Dairy	*100 high-producing cows*	*0*	*0.012*	*0.0070*	*0.0020*	*100 x 0 x 0.012 = 0*	*100 x 0 x 0.0070 = 0*	*100 x 0 x 0.0020 = 0*

Animal Product	H. Milk Produced, lbs/day	I. Nutrient Concentration of Milk			J. Nutrients Secreted in Milk, lbs = H x I		
		N	P	K	N	P	K
Milk[2]	*9,000 lbs/d*	*0.0050*	*0.0010*	*0.0015*	*9,000 x 0.0050 = 45 lbs/d*	*9,000 x 0.0010 = 9.0 lbs/d*	*9,000 x 0.0015 = 13.5 lbs/d*

Nutrient Excretion by Livestock

Animal Group	K. Days Fed per Year	Annual Nutrient Excretion in Elemental Form = K x (C - G) or = K x (C = J) or both				
		N	P	P_2O_5[3]	K	K_2O[3]
Example: 100 high-producing dairy cows	*100 days*	*100 x (154 - 0 - 45) = 10,900 lbs*	*100 x (22 - 0 - 9.0) = 1,300 lbs*	*1,300 x 2.27 = 2,951 lbs P_2O_5*	*100 x (82.5 - 0 - 13.5) = 6,900 lbs*	*6,900 x 1.2 = 8,280 lbs K_2O*

[1]N in feed = Protein ÷ 6.25 [2]N in milk = Protein ÷ 6.45. Assumes 3.2% protein in milk. [3]lbs P_2O_5 = lbs P x 2.27 lbs K_2O = lbs K x 1.2

developing a Phosphorus Index to assess soil P buildup in fields and the potential for P transport from that field. Other states are considering an environmental soil test P level above which no additional manure or fertilizer P can be used in growing the crop on that field. More details on this topic can be found in Lesson 34, Phosphorus Management for Agriculture and the Environment.

Many factors influence manure nutrient excretion and the eventual land base needed for agronomic nutrient application. Decisions regarding ration formulation and feeding strategies (discussed later in this lesson) play a critical role in determining nutrient excretion by dairy cattle.

As milk production of dairy cattle increases, so do the nutrient requirements and the nutrients they excrete. For herds producing between 70 and 100 lbs of milk per cow/day, a 100-cow group will require between 140 and 170 acres to manage the N in the manure, depending on crop rotation and yields (Koelsch 1999). Consequently, to successfully manage N in the manure, you should have access to approximately 1.5 acres per cow. With a greater focus on environmental problems associated with excess soil P levels, access to at least 2.25 acres per cow will be necessary (Koelsch 1999).

The content of protein and P in the ration significantly affects excretion in the manure, and consequently, the land base needed for manure application. Protein not used for milk production or cattle maintenance and growth is excreted as urea or organic N in the manure. Typically, 70% of the N fed to animals as protein is excreted in a diet that is formulated to National Research Council (NRC) (2001) guidelines. Feeding in excess of the NRC guidelines only adds to the N excreted in the manure. Two examples illustrate the tremendous impact that dietary content of N and P have on land needed. A diet containing 19.5% CP (based on alfalfa with no supplemental escape CP) results in about 20% more N in the manure than a diet with only 17.0% CP (containing supplemental escape CP so that total ration CP can be reduced). In this example, 20% more land is needed for manure management for cows fed the higher CP diet. For a 100-cow group of cows, an additional 6 to 25 acres is needed to manage the N in manure. Commonly observed ranges for P levels in dairy rations can exert an even greater impact on land requirements. A ration containing 0.52% P results in 30% more land needed than a 0.43% P diet. Even though the 0.43% P diet meets the cow's requirements, for a 100-cow group, an additional 50 or more acres are needed for managing the extra P.

These examples give you an idea of the effect of ration formulation on land needed for manure application. Obviously, actual land application area needs will vary for each farm for a variety of reasons. To develop an estimate of land needs for any individual farm, use the "Manure Nutrient Inventory" spreadsheet discussed in the previous section. If managed improperly, manure nutrients represent a critical environmental threat. Dairy producers should have access to at least 1.5 acres of land per cow to manage manure in a N-based manure management system utilizing manure storage. Approximately 0.4 acres per cow are needed to manage N for a system with an anaerobic lagoon.

The remainder of this lesson addresses specific issues of N, P, and K nutrition of dairy cows and ration formulation. The goal is to give you the tools to develop a feeding program that minimizes N, P, and K excretion by each group of cattle on your dairy farm.

Phosphorus Requirements, Sources, and Excretion in Dairy Cows

Since the 1960s, several researchers have examined P metabolism in the lactating dairy cow. In the previous NRC (1989) publication on dairy cattle nutrient requirements, P requirements were increased by 10% to 22% to adjust for dietary P availability in common feeds. This publication gives the P requirement as 0.49% for the first 3 weeks of lactation and then 0.38% to 0.42% for cows in early to midlactation.

Recent research from the U.S. Dairy Forage Research Center in Madison, Wisconsin (Satter and Wu 1999, Wu et al. 1998) confirms that high-producing dairy cows require approximately 0.40% P in the dietary dry matter for optimal milk production and reproductive performance. Although it is a common practice to feed 0.50% to 0.60% P in some parts of the United States, these controlled studies indicate no benefit of these high levels. Feeding higher than recommended levels of dietary P has not improved either milk production or reproductive efficiency in controlled research studies. In line with this research, the most recent NRC (2001) recommends lower dietary P levels.

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Phosphorus can be supplemented by adding monocalcium or dicalcium phosphate, monosodium phosphate, ammonium phosphate (*high availability*); steamed bone meal, defluorinated phosphate, sodium tripolyphosphate (*medium availability*); or low-fluorine rock phosphate, soft rock phosphate (*low availability*). Most commercial premixes contain P and must be properly incorporated into the diet.

Phosphorus that is bound to phytate, so-called phytate-P, is not readily available to nonruminant animals such as swine. However, rumen microbes produce phytase, an enzyme that effectively releases P from phytate (Morse 1989). *Phytate-P is readily available to ruminants such as dairy cattle.* Over 99% of P bound to phytate is released from wheat middlings, hominy, soybean meal, corn distillers grains, and cottonseed meal during rumen fermentation of the feedstuff (Morse 1989). *Therefore, do not over-supplement P above recommendations in a mistaken attempt to compensate for phytates in feeds.*

Phosphorus is the most expensive nutrient in typical mineral-vitamin formulations for dairy cattle. For example, feeding a ration containing 0.45% P versus a diet containing 0.55% P would save about $0.05/cow daily. For 100 cows over a year's time, it would save about $1,825.

Dry cows require only 0.25% P in the ration dry matter. A 1,300-pound milk cow, however, requires about 17 grams of P daily for maintenance plus 0.90 grams per every one pound of daily milk production. For example, a 1,300-pound cow producing 85 lbs of milk requires about 94 grams of P daily.

Signs of P deficiency include inactive ovaries and lack of estrus behavior (NRC 1989). Cows may eat wood or dirt or drink urine. Over-supplementation of P generally will not impair performance; the maximum tolerable level is 1.0% of the ration dry matter. However, dry cow health may be impaired when excessive P is fed during the dry period. Over-supplementation of P also leads to increased environmental risks due to excessive P content of the manure. Keep in mind that commonly fed commodity feeds and byproducts can vary substantially from source to source in content of nutrients including P and other minerals. When formulating diets containing byproduct feeds, it

Clearly, a dairy producer has considerable control over mineral excretion in the manure by manipulating the amount of mineral in the feed.

Remember, the goal is to keep excretion of N, P, and K as low as possible while maintaining optimum dairy cow performance.

is important to test regularly for nutrient content and to adjust the ration accordingly. In some cases, using least-cost ingredients increases the diet's P level over NRC (2001) recommendations. For example, a traditional diet containing alfalfa, corn silage, soybean meal, and corn would contain about 0.40% to 0.45% P. In contrast, a diet with 30% to 40% corn gluten feed, although costing less, would contain between 0.55% to 0.60% P. Dairy producers need to weigh the relative feed cost savings versus the potential cost of excess nutrient excretion.

Excretion estimates of P in Table 12-1 show that a dietary P content of 0.40%, 0.45%, or 0.60% results in estimated annual excretion of P of 40 to 46 to 69 pounds per cow. Clearly, a dairy producer has considerable control over mineral excretion in the manure by manipulating the amount of mineral in the feed.

Feeding adequate P is important for cow performance and health, but 0.40% to .45% of the dietary dry matter is near the optimal dietary content for lactating dairy cows. For a cow producing 100 to 120 lbs of milk daily, a diet containing 0.45% P meets the NRC (1989) recommendation. However, the same dietary P level provides about 140% of the daily P requirements for a cow producing only 40 to 50 lbs of milk.

From this observation, we can determine that the milking herd must be grouped by production level and that multiple rations must be formulated over the complete lactation cycle to minimize P excretion into the environment. This is hardly an earth-shattering statement. Remember, the goal is to keep excretion of N, P, and K as low as possible while maintaining optimum dairy cow performance.

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Phosphorus Nutrition and Excretion by Dairy Animals [1]

B. Harris, Jr., D. Morse, H.H. Head and H.H. Van Horn[2]

Phosphorus plays a major role in the structure and function of living cells. It is an integral component of nucleic acids, nucleotides, phospholipids, and proteins, and a key component of many coenzymes. These compounds function in cellular division and growth, in the transport and metabolism of fats, and in the absorption and utilization of carbohydrates, fatty acids, and proteins.

Parturient paresis or milk fever can be a problem in dairy herds (Figure 1) when rations contain less than needed amounts of phosphorus. The phosphorus content of plasma and serum, however, decreases with a chronic or a prolonged deficiency even though the content in milk does not decrease. Phosphorus in bone is mobilized to some extent to maintain normal concentration in blood but at a slow rate since there is no direct mobilizing mechanism for phosphorus as there is for calcium. Since the two elements are combined in bone, the mobilization of calcium, as a result of parathyroid gland action, is accompanied by the incidental mobilization of phosphorus. Animals with chronic phosphorus deficiency sometimes become stiff in the joints and in severe cases, are characterized by fragile bones.

Figure 1.

About 86% of the phosphorus in cattle is found in the skeleton and teeth and the remainder in soft tissues. Bone ash contains about 17% phosphorus. Blood serum varies in concentration from 3.0 to 8.0 mg of phosphorus/deciliter (dL) (Table 1).

Phosphorus is absorbed in the small intestine as phosphate. Since phosphorus combines spontaneously with other elements, it is present in the body in the phosphate form (PO^{-3}). In the bones it occurs as calcium hydroxyapatite. All cells possess enzymes that can attach phosphates in ester or acid anhydride linkages to other molecules. Enzymes exist both inside

and outside of the cells which remove phosphates from phosphate-containing molecules.

Phosphorus Requirements

Phosphorus requirements are highest during lactation, early growth, and for reproduction. High-producing cows need much more phosphorus than cows producing at average or low levels. Dry cows or cows that are not producing milk need less phosphorus than lactating cows due to the high content of phosphorus in milk.

Milk contains about 0.12% calcium and 0.095% phosphorus. A cow producing 100 pounds of milk daily would require 100 g (0.220 lb) of phosphorus and secrete 43 g (0.095 lb) of phosphorus in milk. Because of the high level of phosphorus in milk, a continuous supply is needed in the ration in order to allow high levels of milk production. The amounts of phosphorus required by dairy cattle, as set forth by the subcommittee on Dairy Cattle Nutrition of the National Research Council, are in Tables 2 and 8.

Rations for lactating dairy cattle are formulated to contain a given quantity or percent of phosphorus in order to meet the requirements for that specific nutrient. A lactating dairy cow producing 70 lbs of milk and consuming 47 lbs of dry matter (DM) daily and receiving a ration containing 0.4% phosphorus would receive the needed 82 grams of phosphorus as shown in Table 2 (47 x 0.004 = 0.188 lb x 453.6) = 85 grams.

Dry cows are those not producing milk after having completed a lactation. They are usually separated into two groups and noted as early and late dry cows. Late dry or springer cows are handled more carefully since they are in the last month of gestation when the fetus is growing at an accelerated rate. As shown in Table 3 , they need more phosphorus than the early dry cows.

Growing heifers weighing about 300 pounds need 12 grams of phosphorus daily (Table 2). Since heifers are fed to meet their energy and protein requirements, the total ration dry matter (DM) would need to contain an adequate amount of phosphorus in addition to other required nutrients. A heifer consuming 8.06 pounds of dry matter daily would need a total ration containing 0.33% phosphorus in the DM to provide the needed 12 grams. The phosphorus requirements for growing heifers gradually increases as the animals become more mature, with little to no increase beyond 900 pounds of body weight.

Phosphorus Sources and Availability

Ruminant animals obtain phosphorus from most feedstuffs fed to them. High quality forages tend to be low in phosphorus but concentrates are fairly good sources. Much of the phosphorus found in some cereal grains is bound to a chemical compound named phytate (Table 3). This source of phosphorus is poorly utilized by simple stomached animals (poultry, swine, etc.) but is readily available to ruminants. Ruminants have a true stomach or abomasum as you would find in monogastric animals.

In addition, ruminant animals have three other compartments (Figure 2). The rumen and reticulum make up a large fermentation vat where large numbers of bacteria and protozoa produce many enzymes that aid in digesting the consumed feed. The third compartment, the omasum, provides an absorption area even greater than the rumen.

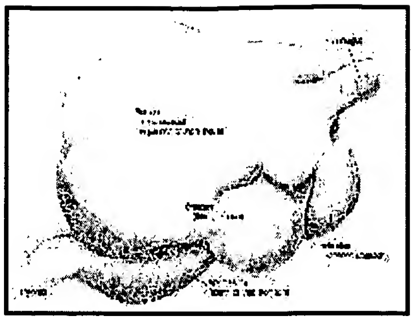

Figure 2.

Because of the unique digestive tract, ruminants utilize feedstuffs after a predigestion in the rumen-reticulum.

The forward location of the rumen gives the microbes priority to the soluble carbohydrates and proteins, as well as vitamins and minerals that are consumed. The more complex carbohydrates such as cellulose and hemicellulose that are in roughages are degraded at a much slower rate than the starches in corn. The microbes attach and degrade the complex feedstuffs into more simple compounds such as fatty acids and amino acids. Also, minerals and vitamins are released in the process and become available to the animal. Such is the case for phosphorus bound to phytate. Rumen microbes produce an enzyme called "phytase" that degrades the complex compound. As a result, phosphorus is released and available for absorption and utilization (Table 3). Recent studies by Clark et al. (1986) and Morse (1989) confirm research by Reid et al. (1947) with sheep which showed that a large percentage of the phosphorus bound to phytate was utilized. Studies by Morse, (1989) indicated that 99% to 100% of the phosphorus bound to phytate was hydrolyzed within a period of about 24 hours in rumen fluid (in vitro studies) and would be available for utilization (Table 4). While phytate phosphorus is well utilized, most dairy cattle rations still require further supplementation with inorganic sources of phosphorus such as defluorinated or dicalcium phosphate.

A number of feedstuffs are relatively high in phosphorus and, when used in combination or at levels of 10%-20%, tend to meet or exceed the requirements for phosphorus in the ration without further supplementation. Some of the more common ingredients high in phosphorus are in Table 5 .

Phosphorus Absorption

Phosphorus absorption occurs in the small intestine. The amount of phosphorus absorbed by the animal depends on the source of the phosphorus, the amount of intake, the calcium-phosphorus ratio, intestinal pH, disease and parasites, environment, the age of the animal, and dietary levels of calcium, iron, aluminum, manganese, potassium, magnesium and fat. Many of these factors become important when nutrients in diets are low or deficient. The regulation of phosphate absorption is mediated by vitamin D, (1,25-dihydroxyvitamin D_3). When the serum phosphate level is abnormally low, the formation of 1,25-dihydroxyvitamin D_3 in the renal tubule of the kidney is stimulated, causing enhanced phosphate absorption from the intestine. Ruminants recycle large amounts of phosphorus as inorganic phosphate in saliva, in which secretion appears to be regulated by the parathyroid hormone. Also, the parathyroid hormone along with vitamin D is involved in the mobilization of calcium and phosphate from bone.

Phosphorus and Milk Fever

An important concern dairymen have when reducing the amount of phosphorus in rations is the impact on milk fever incidence. Milk fever is a metabolic disorder that is associated with the level of phosphorus and calcium intake during the late dry period or very early lactation. It is caused by a sudden drop in the calcium content in the blood. Phosphorus appears to affect the cow's ability to mobilize calcium from bone and to absorb calcium efficiently from the intestine. Noticeable early symptoms are unsteadiness in walking, eyes dull and staring, pupils dilated, sleepy attitude and cold ears. As the case develops, the cow will be found lying down with her head displaced to one side or tucked into her flank. Complete paralysis, coma, and death occur unless an intravenous injection of a calcium solution is given.

During the dry period, it is desirable to not overfeed calcium and to maintain diet calcium and phosphorus near or slightly less than a 1.5 to 1.0 ratio. During lactation, problems are not usually encountered with a wider ratio as long as the level of phosphorus meets the animal's requirements.

Nutrient changes in a ration should be made gradually. This also is the case for phosphorus, especially when moving from a fairly high level to a lower level in the diet. The National Research Council recommends that the total ration dry matter for the late dry pregnant cow contain a minimum of 0.39% calcium, 0.24% phosphorus and 0.16% magnesium. The exact percent needed, however, would depend on the type and amount of ration being fed.

Since milk fever usually occurs at or near the time of calving and is more related to feeding during the late dry period, it is important that a good feeding program be developed for the dry cows. Just as sodium and potassium are associated with udder edema, calcium, phosphorus and sometimes magnesium are associated with the incidence of milk fever in a herd.

In 1964, Harris reported that borderline levels of phosphorus and higher than needed levels of calcium were associated with increased incidence of milk fever in many herds. The high level of calcium (Ca) fed was attributed to the high level of citrus pulp (1-3% Ca) included in the diets (normally 30-45% of diet). To combat the high incidence of milk fever, dietary phosphorus was increased. This simultaneously reduced the Ca:P ratio and reduced the incidence of milk fever. The level of phosphorus in dairy cattle rations tended to increase over the next few years since it was believed that phytate-bound phosphorus was unavailable to animals. As a result, discount values were established for certain feedstuffs. This resulted in a higher level of phosphorus in some rations. Research by Morse (1989) shows that these discount values are unnecessary.

Research to Reduce Excretion

A problem of great concern in South Florida is the concentration of phosphorus in Lake Okeechobee. This large lake (1900 square kilometers) ranging from 5 to 6 meters in depth, supplies drinking water to communities around the lake, serves as reserve water for Florida's southeast coast, and provides water to the Florida everglades. The lake also serves as a recreational facility and provides some of the best sports fishing in the United States. Nutrient rich runoff from farm lands enters the lake and significant phosphorus contamination originates from the dairy farms (>35,000 dairy cows) in the Taylor Creek-Nubbin Slough watershed. As concentration of phosphorus in the lake water increases, algae growth increases which may deplete the water of oxygen and disturb the ecosystem.

Graetz (1989) reported that waters originating from the northern end of the lake contain high concentration of phosphorus in the water. Since phosphorus has been identified as a troublesome nutrient to the ecosystems of Lake Okeechobee, research was needed to better define phosphorus intake versus phosphorus excretion.

Okeechobee Field Trial

During 1986-87, a study was conducted in the Okeechobee area to determine the effects of different levels of phosphorus intake on the excretion of phosphorus in feces. Five dairies, each milking 700 to 1550 cows were included in the study. Production and reproduction data were available for many of the cows sampled. One dairy had only first lactation cows, whereas other dairies had both first and greater lactation cows. Feed for these dairies was supplied by United Feed Cooperative (UFC) or Dairy Feeds, Inc. (DFI).

Concentrate portions of diets were formulated by feed mills for .42% phosphorus on two dairies, and .52% P on three dairies. Free choice mineral mix with minimum of 8.0% phosphorus was available for cows on one dairy where cows were fed .52% phosphorus. Feedstuffs used in the rations formulated included cottonseed hulls, malt sprout pellets, hominy, whole cottonseed, wheat middlings, soybean hulls, corn meal, cottonseed meal and rice bran.

Feed, fecal and bulk milk samples were collected monthly at each dairy. Fecal samples were retrieved per rectum from 20 randomly selected cows on each dairy. Also, samples of whole blood were taken from 10 to 15 randomly selected cows at each dairy. Concentration of phosphorus in the blood serum was an indication of phosphorus status of cows. The results are in Table 6 .

Phosphorus in the feces decreased when the concentration of phosphorus in the ration was decreased. Cows allowed access to free choice mineral had a greater concentration of phosphorus in the feces (MF3 vs MF4). The major dietary difference between cows at MF3 and MF4 was availability of free choice mineral at MF3.

Intake and Excretion

The Okeechobee field trial indicated some relationship exists between phosphorus intake and phosphorus excretion. Lomba et al. (1969) summarized 14 experiments in mature, lactating, non-pregnant dairy cows producing 24 to 44 pounds of milk daily and found no relationship between dietary phosphorus intake and excretion. Two additional experiments were conducted at the University of Florida to evaluate the effects of phosphorus intake on amount and route of phosphorus excretion and on level of phosphorus in diet on voluntary feed intake and milk production.

Twelve Holstein cows were used in a 13-week continuous trial in the first experiment. Cows were assigned randomly to one of three dietary concentrations of phosphorus: .30%, .41% or .56% of diet dry matter (DM). These diets are identified as low (L), medium (M), and high (H) in concentration of phosphorus and represent 79% (deficient), 108% (adequate), and 147% (excess) of recommended nutrient requirements for a 1300-lb dairy cow producing between 46 lb and 70 lb of 4% fat milk daily (NRC, 1988).

The study showed that the concentration of phosphorus in feces was altered by the concentration of phosphorus in the diet but had little or no effect on amount of phosphorus excreted in milk or urine (Table 7). Increasing the intake of phosphorus from 82 g/d to 112 g/d resulted in a 48.6% increase in the excretion of phosphorus in feces. Reducing the intake of phosphorus from 82 g/d to 60 g/d resulted in a 22.7% decrease in the excretion of phosphorus in feces.

Since voluntary feed intake was restricted to 44 lbs of DM/d for these cows, a second trial was

conducted using 24 Holstein cows to study the effect of different levels of dietary phosphorus and Ca on voluntary feed intake and milk production and composition. Levels of phosphorus used were .33%, .43%, and .54% of ration DM. Again, these levels represented less, adequate, or high level of phosphorus in diet of high-producing cows relative to NRC requirement (0.41% of diet DM as phosphorus; NRC, 1988). Concentrations of Ca were .60% and .97% of diet DM representing 100% and 162% of currently recommended concentrations of Ca (NRC, 1988).

Concentrations of dietary phosphorus (.33%, .43%, and .54% of DM) did not affect voluntary intake of feed or production of milk. Although milk production tended to be higher on low phosphorus, the results showed no difference in DM intake for ratios of Ca:P between 1.1:1 and 2.9:1. There was a trend for DM intake to increase with decreased concentration of phosphorus. Production of 3.5% FCM was 4.8% greater in cows fed a .60% calcium diet when compared to cows fed a .97% Ca diet.

Formulating Rations

Consideration should be given to the total ration when formulating premixes, mineral mixtures or the concentrate portion of the ration. A balanced ration is one that provides the nutrients in such proportions and amounts that will properly nourish a given animal for 24 hours (Morrison, 1956). In addition, consideration must be given to the amount of dry matter the animal is able to or will consume during the 24-hour period. In formulating rations, a number of components are usually considered such as protein, energy, fiber, minerals and vitamins. In this discussion, we are primarily interested in the level of phosphorus in rations and how it relates to calcium, magnesium, protein and energy.

Some feedstuffs are better sources of minerals than others (Table 3). While textbook values are commonly used for many feedstuffs, an analysis of the forage is preferred since they vary considerably in composition. This is especially true for legume forages which are relatively high in minerals.

In addition to formulating balanced rations for dairy cattle, attention must be given to meeting the nutrient requirements of the cow at the lowest possible cost. Computer programs are available to assist in the formulation of optimum diets at minimum costs. Table 8 contains the requirements for calcium and phosphorus for lactating cows (NRC, 1988).

A few examples of total mixed rations are presented to show the level of calcium and phosphorus needed by dairy cattle as outlined in Table 8.

Ration 1 (Table 9) is a high energy ration that contains 0.79% calcium and 0.48% phosphorus on a dry basis. Since ration 2 (Table 10) contains a lower energy roughage source, less calcium and phosphorus is needed as a percent of the dry matter since dry matter intakes are greater when cows receive cottonseed hull rations.

Ration 3 (Table 11) contains rice bran which is an excellent source of phosphorus. Note that the mineral supplement contains no phosphorus. Ration 4 (Table 12) contains some green chop and bermuda hay in addition to a purchased grain mix that contains cottonseed hulls.

Many Florida dairymen purchase a premix or concentrate to blend with the forages available on the farm. Since forages tend to be low in phosphorus, a greater percent of phosphorus is needed in the concentrate. Such is the case with rations 1, 2, 3 and 4 where both the forage type and amount varies in the ration and the percent in the total ration dry matter varies from 0.43 to 0.49%.

Summary

Phosphorus is an important mineral element which is key to energy metabolism and is an essential component of buffer systems in blood and other body fluids.

Phosphorus requirements of dairy cows vary according to level of milk production, body size and stage of gestation. As an example, a 1400-lb dairy cow producing 85 lbs of 3.5% milk needs about 88 g (.20 lbs) of phosphorus daily as compared to 59 g (.13 lbs) for a similar cow producing 50 lbs of milk (NRC, 1988).

Phosphorus bound to phytate accounts for a large amount of the phosphorus present in feedstuffs commonly fed to dairy cattle. The results of our studies revealed that 99% to 100% of the phosphorus bound to phytate would be hydrolyzed in the digestive tract and be available for utilization. There was no evidence to indicate or suggest any discounting value of phosphorus bound to phytate when formulating diets for lactating dairy cows.

Phosphorus is excreted primarily through feces and milk. The level of phosphorus in milk appears to remain constant with different levels of phosphorus in the ration. Once cows attain a balance of phosphorus for body functions and needs, the amount of phosphorus excreted in the feces will increase.

Research indicates that the NRC (1988) recommended level of phosphorus (0.4 to 0.43% of ration dry matter) for lactating dairy cows is enough for optimum performance. Feeding more increases the amount excreted in the feces. Restricting dietary intake of phosphorus to NRC allowances will help to reduce the amount of phosphorus excreted in the feces while providing adequate phosphorus for other body functions.

Selected References

1. Clark, W. D., Jr., J. E. Wohlt, R.L. Gilbreath, and P. K Zajac 1986. "Phytate phosphorus intake and disappearance in the gastrointestinal tract of high producing dairy cows." *J. Dairy Sci* . 69:3151.
2. Graetz, D.A. 1989. "Phosphorus levels in soils of selected Lake Okeechobee watershed dairies." Proc. Florida Dairy Production Conf., Gainesville, Fl. pp.113-118.
3. Harris, B. Jr. 1964. "Minerals in dairy rations." Florida Dairy Extension Newsletter.
4. Lomba, F.,R. Paguay, V. Bienfet, and A. Lousse. 1969. "Statistical research on the fats of dietary mineral elements in dry and lactating cows." III. Phosphorus. *J. Agric. Sci* . 73:215
5. Morrison, F. B. 1956. "Feeds and feeding". 22nd Ed. The Morrison Publishing Co., Clinton, Iowa.
6. Morse, D. 1989. "Studies of modification of phosphorus concentration in diets, hydrolysis of phytate bound phosphorus, and excretion of phosphorus by dairy cows." Ph.D. Dissertation
7. National Research Council. 1988. "Nutrient requirements of dairy cattle," 6th rev. ed. Washington, D.C.: National Academy Press.
8. Reid, R.L., M. C. Franklin, and E. G. Hallsworth. 1947. "The utilization of phytate phosphorus by sheep." *Aust. Vet. J* . 23:136.

Tables

Table 1.

Table 1. Normal levels of selected minerals in blood serum.	
Component	Normal Values (mg/dL)[1]
Calcium	9-10.6
Magnesium	1-3
Phosphorus	3-8
Potassium	14-20
Sodium	310-340
1dL=0.1 liter or 100 milliliters.	

Table 2.

Table 2. Daily nutrient requirements for growing, dry, and lactating ddairy cattle (3.5% fat, 1400 lb body wt.)							
Live wt (lb)	Gain (lb)	Milk Yield (lb)	Minerals		DMI	TDN	CP
			Ca (gms)	Phos (gms) 1	---------------------------lbs--------- ---------------------		
90	0.6	-	6.8	4.1	1	1.32	0.24
150	1.7	-	15.4	7.7	4	3.92	0.77
300	1.7	-	19.5	11.4	8	5.56	1.29
700	1.7	-	24.9	18.6	16	10.27	1.94
900	1.7	-	28.6	20.9	21	12.75	2.52
1400	-	(Dry)	25.9	18.2	-	12.75	2.52
1400	-	(Late Dry)	41.8	25.4	-	12.90	2.20
1400	-	35	73.5	46.7	35	21.00	4.20
1400	-	70	121.1	75.3	47	30.83	6.90
1400	-	100	162.0	100.0	58	39.90	9.27
1453.6 grams = 1 pound; DMI =dry matter intake; TDN =total digestible nutrients; CP =crude protein.							

Table 3.

Table 3. Concentration of total phosphorus and phosphorus bound to phytate in selected feedstuffs.				
Feedstuff	Number Samples	Total Phos.	Phytate	Phytate Phos.
		----------------------------ppm[1]------- ----------------		%

Cottonseed meal	2	12220	8480	69.4
Distillers, dried	2	8990	2880	32.0
Corn meal	3	2980	1900	63.8
Hominy feed	3	6380	4680	73.4
Peanut meal	2	6650	3800	57.1
Rice bran	2	15780	12560	79.6
Soybean meal	2	7320	5020	68.6
Wheat midds	3	13400	10480	78.2
1ppm = parts per million				

Table 4.

Table 4. Percent disappearance of P bound to phytate with time in rumen fluid.				
Ingredient	Hours of Incubation in Rumen Fluid[1]			
	2	6	12	24
Wheat midds	84.5	94.9	98.1	99.8
Rice bran	85.3	82.6	98.1	99.8
Hominy feed	52.5	90.0	99.4	99.8
Soybean meal	31.3	50.2	99.9	100
Dried distillers grain	71.3	95.4	98.7	99.3
Cottonseed meal	48.7	57.0	71.5	99.9
1Morse, 1989.				

Table 5.

Table 5. Feedstuffs commonly used in Dairy Cattle Rations (as fed).				
Feedstuff	CP[1] %)	TDN[1] (%)	Calcium (%)	Phosphorus (%)
Canola meal	37	64	.68	1.10
Corn gluten feed	21	74	.30	.76
Corn gluten meal	60	82	.02	.62
Cottonseed, whole	21	90	.14	.68
Cottonseed meal	41	70	.20	.90
Malt sprouts	20	65	.20	.70
Peanut meal	50	74	.20	.60
Rice bran	12	60	.60	1.40
Rice mill feed	6	32	.08	1.30

Soybean meal	44	78	.20	.60
Wheat midds	16	76	.10	.90
1CP = crude protein; TDN = total digestible nutrients				

Table 6.

Table 6. Concentration of phosphorus found in the concentrate, feces and blood serum of dairy cows.			
	Phosphorus Concentration		
	Total diet (% of DM)	feces (ppm)	serum (mg/dL)
DLD 1[a]	0.57	7317	5.98
DLD 2 (Low)	0.47	6344	6.33
MF 1 (Low)	0.51	6942	5.89
MF 3 (free choice)	0.71	9533	6.28
MF 4	0.71	8931	6.01
aDLD= Dry Lake Dairies Barns 1 and 2. MF- McArthur Farms Barns 1,3, and 4.			

Table 7.

Table 7. Least squares means for three levels of phosphorus on excretion of phosphorus in feces, milk and urine.			
Measurement	Low (.30 %; 60 g/d)	Medium (.41 %; 82 g/d)	High (.56 %; 112 g/d)
Feces (g/d)	40.30	45.10	62.94
Milk (g/d)	18.40	20.40	22.00
Urine (g/d)	.66	1.26	3.36

Table 8.

Table 8. Calcium and phosphorus requirements of small cows producing 4.5% milk fat and larger cows producing 3.5 % milk fat.							
Wt.	Milk	Ca.	Phos.	Wt.	Milk	Ca.	Phos.
--lb----------------------------------				--lb---------------------------------			
1000	35	.164	.103	1000	75	.304	.187
1400	35	.162	.103	1400	75	.282	.175
1000	50	.216	.134	1400	80	.297	.184
1400	50	.207	.130	1400	85	.312	.193
1000	65	.269	.166	1400	90	.327	.202

1400	65	.252	.157	1400	100	.357	.220

Table 9.

Table 9. Ration No. 1							
	lbs.	Dry Matter	Crude Protein	TDN	CA	PHOS	Crude Fiber
		--lbs---------------------------------					
Corn Silage	45.00	13.50	1.13	9.00	0.04	0.02	4.05
Alfalfa Hay	6.00	5.34	1.08	3.00	0.05	0.01	1.68
Corn Meal	8.00	7.20	0.69	6.40	.00	0.02	0.24
Whole Cottonseed	5.00	4.50	1.05	4.50	0.01	0.03	0.85
Wheat Midds	3.00	2.67	0.48	2.28	.00	0.03	0.18
Soybean Hulls	3.00	2.67	0.36	1.95	0.01	.00	0.36
Distillers grains	3.00	2.70	0.78	2.40	.00	0.01	0.36
Soybean meal (48 %)	4.20	3.78	2.02	3.19	0.01	0.03	0.08
Mineral	1.40	1.32	0.00	0.00	0.02	0.05	0.00
Total Intake	78.60	43.68	7.58	32.72	0.34	0.21	7.80
Requirements (70 # Milk)			7.50	32.30	0.32	0.20	-
Ration Percent Dry Matter			17.35	74.92	0.79	0.48	17.87

Table 10.

Table 10. Ration No. 2							
	lbs.	Dry Matter	Crude Protein	TDN	CA	PHOS	Crude Fiber
		--lbs--					
Cottonseed hulls	12.00	10.00	0.48	4.80	0.02	0.01	5.16
Alfalfa Hay	8.00	7.12	1.44	4.00	0.06	0.02	2.24
Corn Meal	11.00	9.90	0.95	8.80	.00	0.03	0.33
Whole Cottonseed	5.00	4.50	1.05	4.50	0.01	0.03	0.85

Wheat Midds	4.00	3.56	0.64	3.04	.00	0.04	0.24
Soybean Hulls	3.00	2.67	0.36	1.95	0.01	.00	0.36
Distillers grains	3.00	2.70	0.78	2.40	.00	0.01	0.36
Soybean meal (48 %)	4.00	3.60	2.92	3.04	0.01	0.02	0.08
Mineral	1.50	1.41	0.00	0.00	0.24	0.04	0.00
Total Intake	51.50	46.26	7.62	32.53	0.35	0.21	9.62
Requirements (70 # Milk)			7.50	32.30	0.32	0.20	-
Ration Percent Dry Matter			16.46	70.32	0.76	0.45	20.80

Table 11.

Table 11. Ration No. 3							
	lbs.	Dry Matter	Crude Protein	TDN	CA	PHOS	Crude Fiber
		---lbs---					
Cottoonseed Hulls	13.00	11.70	0.52	5.20	0.02	0.01	5.59
Bermuda Hay	6.00	5.34	1.02	2.28	0.02	0.01	1.92
Hominy Feed	15.00	13.50	1.50	12.30	0.01	0.08	0.45
Whole Cottonseed	5.50	4.95	1.16	4.95	0.01	0.04	0.94
Rice Bran	4.00	3.56	0.48	2.40	.00	0.06	0.40
Distillers Grains	3.00	2.70	0.78	2.40	.00	0.01	0.36
Peanut Meal	4.20	3.78	2.10	3.19	0.01	0.03	0.17
Mineral	1.60	1.50	0.00	0.00	0.28	0.00	0.00
Total Intake	52.30	47.03	7.56	32.72	0.34	0.23	9.82
Requirements (70 # Milk)			7.50	32.30	0.32	0.20	-
Ration Percent Dry Matter			16.06	69.57	0.72	0.49	20.88

Table 12.

Table 12. Ration No. 4							
	lbs.	Dry Matter	Crude Protein	TDN	CA	PHOS	Crude Fiber
		---lbs---					
Bermuda Hay	7.00	6.16	0.49	2.80	0.02	0.01	2.24
CSH Grain Mix	41.00	36.90	6.56	26.65	0.31	0.19	6.15
Green Chop	30.00	6.00	0.45	3.60	0.02	0.01	1.80
Total Intake	78.00	49.06	7.50	33.05	0.35	0.21	10.19
Requirements (70 # Milk)			7.50	32.30	0.32	0.20	-
Ration Percent Dry Matter			15.29	67.37	0.71	0.43	20.77

Footnotes

1. This document is CIR849, one of a series of the Animal Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date February 1990. Reviewed June 2003. Visit the EDIS Web Site at http://edis.ifas.ufl.edu.

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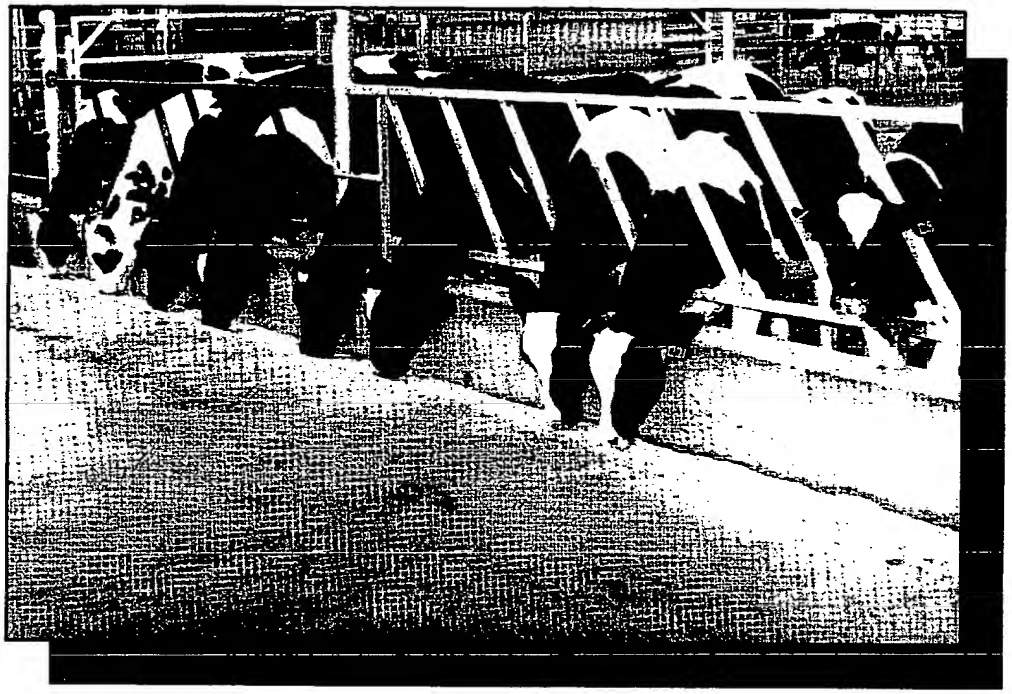

Feeding Dairy Cows

Cooperative Extension Service ■ Kansas State University ■ Manhattan

The dairy feeding program affects productivity and profitability more than any other single factor. The effects of good breeding and management programs cannot be fully realized without good feeding programs. Likewise, good management of cows with good genetic potential will result in the most efficient response to good nutrition.

Feeding for high milk production is efficient since the nutrient requirement for maintenance comprises a smaller portion of the total requirement of high-producing cows. This is reflected in Table 1 by higher milk:feed ratios as production increases in DHIA production-tested herds. Therefore, feed cost per hundred weight of milk produced is less in high producing herds.

Table 1. Effects of Production Level on Milk:Feed Ratio

Milk/cow/year (lb)	12,047	15,025	18,857
Grain/cow/year (lb)	6,183	7,273	8,275
Forage dry matter/cow/year (lb)	7,151	7,784	8,096
Milk to Feed ratio	0.90	1.00	1.15

The purpose of this publication, then, is to provide the information needed to develop feeding programs for efficient milk production.

Nutrients Needed

Feeding dairy cows for efficient production involves supplying the five classes of nutrients in proper amounts. These include:

1. ENERGY. The unit of measurement of energy for dairy cows is Net Energy for Lactation (NEL). The Net Energy for Maintenance (NEM) value of feedstuffs for dairy cows is similar to NEL; therefore, the NEL value of feeds is used when calculating rations.

The main sources of energy are provided by carbohydrates and fats. Protein can be metabolized for energy, but it is an expensive source of energy. The carbohydrates of feedstuffs include starch, simple sugars, and cellulose in the crude fiber.

Dairy cows demand a large supply of energy for maintenance, milk production, reproduction, growth, and weight gain. High producing cows usually cannot consume enough feed during early lactation to meet their requirements. The energy deficiency is made-up by converting body fat to energy. However, this loss of body weight should be kept to a minimum to avoid metabolic disturbances.

The crude fiber content of forages is inversely related to energy content. As forages mature, crude fiber becomes more lignified and, thus, less digestible. Acid Detergent Fiber (ADF) is an indicator of lignification. Neutral Detergent Fiber (NDF) is a measure of the amount of cell walls in feeds. The NDF content of a feed is a good indicator of consumption since cows will eat about one pound of NDF/body cwt.

2. PROTEIN. The best sources of protein include legume forages and the oil seed meals. Grain and non-legume forage are somewhat deficient in protein and usually require supplementation for dairy rations.

Protein is required for maintenance, milk production, reproduction, and growth. Unlike energy, protein cannot be mobilized in significant amounts when the requirement is greater than the demand. Therefore, adequate amounts of protein must be supplied daily in order to avoid depressed milk production.

Dairy rations have traditionally been balanced for the Crude Protein (CP) requirements. More recently, some research has shown that the CP of some feeds is converted to ammonia too readily in the rumen and, therefore, is absorbed and wasted in the urine. The CP which is converted to ammonia is designated Degraded Intake Protein (DIP), also known as soluble protein. Since high-producing dairy cows require large amounts of CP, the possibility exists that ammonia is released from certain feeds more rapidly than the rumen microbes can convert it into microbial protein.

The portion of crude protein which is not converted to ammonia in the rumen is termed Undergraded Intake Protein (UIP), also known as by-pass protein. Since the proportion of UIP to DIP varies somewhat in different feeds, the National Research Council's Subcommittee on

Dairy Cattle Nutrition has made recommendations for the UIP and DIP content of rations *(Appendix Table 2)*. However, the UIP content of many feeds has not been determined, or the UIP content of some feeds is based upon a limited number of samples. Therefore, general recommendations for the requirements of UIP and DIP is based upon limited data. It appears that performance will be equal with slightly less CP in the ration using UIP and DIP guidelines. However, precaution should be taken to not feed too much UIP since milk production, DM consumption and milk protein test may be reduced.

3. MINERALS. The major minerals not adequately supplied by most feedstuffs are (1) calcium, (2) phosphorus, and (3) salt. In certain localities, magnesium may need to be supplemented and rations containing extremely large amounts of grain and small amounts of forage may need supplemental potassium.

Calcium and phosphorus are necessary for maintenance, milk production, reproduction, and growth. Most rations will require supplementation with calcium and phosphorus.

Salt is required for metabolic purposes and to maintain osmotic pressure in the body tissues. It is recommended that trace mineralized salt be supplemented to insure adequate supplies of trace minerals.

4. VITAMINS. With the exception of vitamins A and D, the other vitamins needed by dairy cows are generally believed to be present in adequate amounts in normal feedstuffs or are manufactured in adequate quantities by microorganisms in the rumen. Supplementation at the rate of 2,000 I.U. vitamin A and 1,000 I.U. vitamin D per pound of grain mix is adequate.

5. WATER. Although not thought of as a nutrient, large quantities of water are required by dairy cows for normal metabolic functions. Depending upon the temperature and the moisture content of feedstuffs, dairy cows will consume from 3 to 5 pounds of water for each pound of milk produced.

Selecting a Forage Program

Every dairy feeding program should be built around quality forages. The grain mix portion of the ration is fed only to supplement the deficiencies of the forages. Even though grain mixes can be formulated to supplement any forage, the performance of dairy cows will be limited when poor quality forage is fed because the amount of consumption will be reduced.

There is no single best forage program, all have some advantages and disadvantages which include:

	Advantages	Disadvantages
Hay	1. Protein content can be high 2. Some hay is desirable in the ration to maintain rumen function 3. Low equipment and facilities cost	1. High labor requirement 2. Waste may be a problem 3. Greater risk from weather at harvest 4. Tonnage is usually lower than row-crop silage
Haylage	1. Protein content can be high 2. Adapted to automation 3. Less weather risk at harvest 4. Reduced waste	1. Nutrient loss from spoilage can be significant 2. High investment in equipment and facilities 3. Limited market for surplus forage 4. Tonnage is usually lower than row-crop silage
Row-Crop Silage	1. High tonnage 2. Adapted to automation 3. Reduced waste	1. High investment 2. Low protein content 3. Nutrient loss from spoilage can be high 4. Limited market for surplus
Pasture	1. Low harvesting cost 2. Reduces time spent on concrete 3. Manure is spread	1. Not well adapted to large herds or confinement systems 2. Quality varies through the season

The final basis for selecting a forage program should depend on the equipment and facilities available and/or the availability of capital. To a lesser extent, the forage program selected will be affected by the soil type and availability of labor.

Selecting Forages

Alfalfa makes up at least a portion of the ration for most dairies. Although it is not absolutely essential in dairy rations, most producers prefer to include at least six to eight pounds in the ration. Alfalfa is very palatable and can provide a significant part of the protein, energy and mineral requirements, which makes it extremely valuable when protein supplements are expensive. Yet, the quality of alfalfa can be quite variable, depending on the stage of maturity at harvest, and the harvest and spoilage losses.

Alfalfa should be harvested at the bud stage of maturity or when regrowth is starting at the root crown. Waiting longer will reduce protein and increase fiber, resulting in lower quality forage. When making hay, care should be taken to avoid leaf loss, but heat damage to the protein may occur if alfalfa is baled too wet.

The moisture content of alfalfa haylage affects quality. Alfalfa haylage which is too wet will lack palatability due to undesirable fermentations, while haylage which is too dry will heat in the silo, causing reduced protein digestibility as evidenced by brown discoloration. Ideal moisture content is 55 to 65 percent for haylage.

Brome can be a good hay crop for dairy cows, but quality can be quite variable. After the brome plant starts heading, fiber content is increased and protein content is decreased. For best results brome should be cut while in the boot stage of maturity.

Cereal crops such as wheat, oats, rye, and triticale can make good hay or haylage. The protein content is good and fiber is reasonably low if harvested in the boot stage. Quality deteriorates rapidly past the boot stage.

Fescue can be a productive forage crop, but the palatability may limit consumption. For this reason it should not provide a major portion of a forage program, other than for dry cows and heifers.

Sudan and Sorghum-Sudan crosses can be used for summer pasture, green chopping, hay, or haylage. Stage of maturity affects the quality of these crops drastically. For best results, these forages should be harvested when less than 30 inches high. Also, during periods of stress, nitrate and prussic acid may accumulate and be toxic.

Corn Silage is recognized as the choice for row-crop silage. Its high yield of palatable energy-rich forage makes it the choice for row-crop silage where corn can be grown. However, corn silage is deficient in protein, and more expensive feeding programs may result when protein supplements are expensive.

The protein content of corn silage can be increased significantly by the addition of anhydrous ammonia. The moisture content (about 65 percent) and acidity of corn silage makes the utilization of anhydrous ammonia very effective when added at the rate of 7 pounds per ton. On a day matter basis, the protein content can be increased from 2 to 4 percentage points after ammoniation.

Sorghum Silage is used extensively in dairy forage programs, but compared to corn silage, dairy cows utilize only about 80 percent as much of the available energy in sorghum silage. More than likely, the reduced energy value of sorghum silage is due to seed passing through the digestive system undigested. So, sorghum silage production should be limited to areas where corn silage cannot be grown and limited to less than 50 percent of the forage DM intake.

The protein content of sorghum silage is similar to corn silage and is low compared to alfalfa. The use of anhydrous ammonia in sorghum silage is recommended.

Selecting Concentrates

Grains commonly used in dairy rations include: corn, milo, barley, oats, and wheat. Their major function is a source of energy. Barley, oats, and wheat can contribute significantly to the protein content of the ration, but palatability problems may occur when the grain mixture exceeds 40 percent wheat. The main consideration in selecting grains for dairy rations is price.

High moisture corn and milo are used extensively in dairy rations. These feeds are quite palatable but do not offer any nutritional advantages compared to dry grain. It has been shown that high moisture grains are equal to dry grains on a dry matter basis. When formulating rations containing high moisture grain, adjustments should be made to account for their lower dry matter content.

Protein supplement is required in most grain mixtures for dairy cows. Because the dairy cow is a ruminant, there are a variety of protein supplements which can be fed with good results.

Soybean meal is fed extensively in Kansas, mainly due to price. Other oil seed meals, such as cottonseed meal and linseed meal, may be fed with good results when favorably priced.

Occasionally, soybeans are competitive, price-wise, with other protein supplements and are a good supplement when a few restrictions are considered. First, the high oil content of soybeans (18 percent) causes a laxative effect when more than 20 percent of the grain mix is soybeans. The high oil content does increase the energy content about 20 percent above soybean meal, while the protein content is reduced from 44 percent in soybean meal down to 38 percent in soybeans. Second, soybeans need to be ground fresh (about every week) to avoid rancidity in the oil. Third, urea should not be mixed with raw soybeans since it will be converted to ammonia due to the urease contained in raw soybeans and will cause palatability problems.

Commercial protein supplements are used extensively in dairy rations. They are usually made from soybean meal and other by-product feeds. Most commercial supplements will be supplemented with vitamins and minerals, which can be convenient for on-the-farm mixing.

Some commercial supplements contain urea and therefore will have less energy. The urea content of

commercial supplements can be estimated by dividing the "equivalent crude protein from non-protein nitrogen (NPN)" by 2.81. *Example:* The feed tag shows the equivalent crude protein from NPN as not more than 12 percent, then the urea percentage is: 12 divided by 2.81 = 4.2 percent urea.

Urea is a source of NPN which can be added to grain mixes as a source of protein. Although urea does not add protein as such, it furnishes ammonia which can be incorporated into the building blocks of protein—amino acids—by the microorganisms in the rumen. Urea contains no energy, therefore, carbohydrates from other ingredients in the ration must furnish carbon for the formation of amino acids. Urea is unpalatable in grain mixes and may result in poor consumption, particularly when fed in the milking parlor. The amount of urea fed should be limited to about 0.25 pound per cow daily. For best results, urea should be incorporated with silage to mask the palatability problem and to allow the cows to consume it at a slower rate.

By-product feeds are common ingredients in commercial feeds and are being fed as individual ingredients in many dairy rations. Many by-products can be good sources of energy and/or protein at reasonable cost if freight is not too expensive.

- Brewers dried grains is a medium protein feed with a relatively high UIP value. It has about 75 percent as much energy as corn due to its relatively high fiber content. Brewers dried grains tends to be bulky and dusty and palatability may be a problem when included in grain mixtures at rates higher than 25 percent or nine pounds/cow daily.

- Corn gluten feed is a medium protein by-product which contains about the same energy as milo. It can be unpalatable when included in grain mixtures at levels higher than 25 percent or when fed at rates higher than nine pounds/day.

- Corn gluten meal is a concentrated source of relatively high UIP protein. It is usually not included in grain mixtures at levels greater than 15 percent or fed at a rate greater than five pounds/day due to poor palatability. Also, the requirement for UIP may be exceeded when fed at high levels.

- Whole cottonseed is an excellent source of protein, energy and fiber. Due to its lint, cottonseed contains about 22 percent crude fiber or 31 percent ADF (as fed) making it desirable to feed in high-energy rations which are low in fiber. Since cottonseed contains 22 percent oil, the amount fed should be limited to about six pounds/cow daily.

- Cottonseed hulls is a by-product which is low in protein and energy and high in fiber. Sometimes it is included in high-energy rations to increase the fiber content.

- Distillers dried grains is a good energy source and medium in protein with relatively high UIP. Its nutrient content will vary depending on the original grain source. Distillers dried grains is a palatable feedstuff and can be fed in large amounts.

- Hominy feed is slightly higher than corn in energy and protein content. The fat content can be variable depending on the manufacturing process, so the fat content should be guaranteed by the supplier. Hominy feed is palatable, but it may not flow well through automated feeding systems.

- Soy hulls is a by-product which is similar to milo in nutrient content. It may make up 45 percent of grain mixtures or be fed up to 12 pounds/cow daily.

- Wheat bran is higher in protein, phosphorus and fiber than grains but is lower in energy. It is bulky and, therefore, will not flow through feeding systems unless mixed with other grains. Wheat bran is palatable, but should be limited to 25 percent of the grain mixture or 7 pounds/cow daily due to its laxative nature.

- Wheat mids is higher in protein and lower in energy than most grains: It is palatable and can be fed in large amounts if dustiness is not a problem.

Feed Additives

Minerals requiring supplementation in dairy rations include: (1) calcium, (2) phosphorus, and (3) salt (sodium and chlorine). Large quantities of calcium and phosphorus are needed for milk production. Many mineral supplements are available for supplementing calcium and phosphorus, and the basis for selecting a supplement should depend on the content of these elements in the supplement in relation to their requirements for supplementation. Salt is required for supplementing sodium and chlorine. Rations which include sodium bicarbonate may not require supplemental sodium; however, salt should be force fed at the rate of 0.5 percent of the grain mix to prevent a chlorine deficiency.

Trace Minerals are usually considered available in adequate amounts in most Kansas grown feeds. However, a trace mineral premix or trace mineralized salt is recommended to ensure that adequate amounts of trace minerals are fed.

Antibiotics have been added to dairy rations to reduce stress. However, considering the level permissible in dairy rations (70 mg/day), it is doubtful that the addition of antibiotics in rations for lactating dairy cows is beneficial. Antibiotics fed in excess can be secreted in milk.

Fats and oils are considered as additives for supplementing energy since the caloric content is 2.25 times that of carbohydrates. Addition of fat or oil can increase the energy concentration of a grain mixture significantly, but should only be considered when it is not feasible to feed more grain to high producing cows. The rate of supplementing fat or oil to grain mixes should be limited to 1 lb/cow daily.

Molasses can be added to control dustiness and improve palatability of grain mixes, especially for parlor feeding. There is no need for molasses in grain mixtures to be fed outside because palatability is usually not a problem. Molasses is a readily available source of carbohydrates but is not a concentrated source of energy. The addition of molasses should be limited to less than 5 percent of the grain mix since digestibility of other carbohydrates may be depressed.

Buffers are needed in high energy rations to control the acidity of the rumen. Depressed milk fat tests and digestive upsets may occur if the ration is not buffered properly. Sodium bicarbonate fed at the rate of 1.5 percent of the grain mix is effective for this purpose. Magnesium oxide, although not a true buffer of the rumen, can improve milk fat tests when fed at the rate of 0.75 percent of the grain mix in combination with 1.5 percent sodium bicarbonate. Sodium bentonite, a clay mineral, fed at the rate of 5 percent of the grain mix, has improved milk fat tests somewhat, although not as effectively as a sodium bicarbonate-magnesium oxide combination. Calcium carbonate has been referred to as a buffer, but it is not soluble in the rumen and therefore will only buffer the small intestine. Its need has not been well demonstrated.

Feeding Systems

The goal of any feeding system on a modern dairy farm should be to deliver the correct amount of nutrients needed to meet the individual cow's requirements. This means the system can provide more nutrients to high producers and can restrict nutrient intake to lower-producing cows. Therefore, in one fashion or another, a good feeding system splits cows into production groups and provides nutrients according to production requirements.

Although the split herd system is not the most common feeding system in Kansas, it offers several advantages over a one-group feeding system. Most herds are not split into production groups because of limited herd size or because the existing facilities do not adapt well to the split herd system. If the herd size is large enough, four production groups (high, medium and low) are recommended, plus a group of first lactation heifers. Of course, an additional group for dry cows is always recommended whether the split herd system is used or not.

Herds split according to production can be managed more efficiently at milking time, and heat detection and breeding can be handled more efficiently. Cows grouped by production milk-out at a uniform rate, smaller groups mean less time in the holding pen, and most of the postpartum reproductive exams, heat detection, and pregnancy exams can be done in the high-production group.

Feeding can be done efficiently with the split herd system, thus reducing the problem of underfeeding some cows and overfeeding others. Also, in some situations, the quality of the forage can be selected according to production. A disadvantage of the split herd system is that cows have to go through some adjustments when moved from one group to another.

The following are some feeding systems that may adapt to a split herd or non-split herd system.

SPLIT HERD	NON-SPLIT HERD
1. Hay and Grain	**1. Hay and Grain**
A. Magnet or computer feeder can be used.	A. Magnet or computer feeder should be used.
B. One forage program eliminates selective feeding.	B. One forage program eliminates selective feeding.
C. Buffer needed only for high producers.	C. Buffer needed for all cows.
D. Only one forage harvesting system needed.	D. Only one forage harvesting system needed.
E. Inexpensive storage.	E. Inexpensive storage.
2. Hay, Silage and Grain	**2. Hay, Silage and Grain**
A. Magnet or computer feeder can be used.	A. Magnet or computer feeder should be used.
B. Selective feeding can be a problem.	B. Selective feeding can be a problem.
C. Buffer needed only for high producers.	C. Buffer needed for all cows
D. More investment in forage harvesting equipment.	D. More investment in forage harvesting equipment.
E. More expensive storage in permanent structures.	E. More expensive storage in permanent structures.
F. More automation.	F. More automation.
G. More feed produced/acre.	G. More feed produced/acre.
3. Total Mixed Ration (TMR)	**3. Total Mixed Ration (TMR)**
A. Eliminates selective feeding.	A. Eliminates selective feeding.
B. Grain consumed at slower rate.	B. Grain consumed at slower rate.
C. Magnet or computer feeder can be used.	C. Magnet or computer feeder should be used.
D. More automation.	D. More automation.
E. Best adapted to silage program.	E. Best adapted to silage program.
F. Requires additional equipment.	F. Requires additional equipment.
G. Buffer needed only for high producers.	G. Buffer needed for all cows.

Throughout this discussion parlor feeding has not been mentioned. It is felt that parlor feeding only complicates a feeding program. There can be little control over amounts consumed in the parlor, and most high-producing cows need additional grain mix. Therefore, it is difficult to feed the correct amounts of additional nutrients outside. One of the most common reasons for feeding in the parlor is to encourage the cows to come into the parlor. However, cows that are coming into the parlor because they are hungry have been hungry too long!

Computerized Feeders

Computerized feeding systems provide a means of feeding cows individually. Herds which are not split according to production face the problem of overfeeding low producers and underfeeding high producers–both are expensive. The magnet feeding system can eliminate the problem of underfeeding, but in most cases, some cows are overfed. The economic advantage of a computerized feeding system would be due to increased production and/or reduced grain cost. Other advantages include:

- Feeding additional supplements to fresh cows with dual ration systems.
- Starting cows on feed in rapid step-wise fashion.
- Reducing grain consumption gradually as production decreases.
- Detecting abnormal conditions of cows by monitoring grain consumption.

To evaluate the potential economic advantage of a computerized feeding system, a producer needs to estimate how much grain could be saved by feeding the low-producing cows less and how much production could be increased by feeding the high producers more. This evaluation can be made by comparing the amount of grain fed versus grain needed for each cow on the DHIA-200 report. An example herd shows the following:

	No.	lbs grain	Expected Change in Milk
Cows overfed	27	96	
Cows underfed	29	-66	+132
Cows no change	12	—	—
	68	-30 lb	+132

In this herd the average grain consumption was about equal to the amount of grain needed. However, there were 27 cows being overfed and 29 cows being underfed. Assuming a 2-lb increase in milk production for each additional pound of grain, there could be 132 lb extra milk produced daily by feeding 66 lb more grain to the underfed cows. Additional savings could be realized by feeding 96 lb less grain to the overfed cows. Hence, the economic advantage of a computerized feeding system can be substantial, depending on the price of milk and grain.

Balancing Dairy Rations

The summit milk yield and stage of lactation profile of a herd *(Figure 1)* can be a reflection of the feeding program. High-producing herds establish a higher summit milk yield after freshening than lower producing herds, probably due to nutrition. After the summit milk yield has been established, the stage of lactation profile indicates that higher production is maintained throughout all stages of lactation. Therefore production in lower producing herds seems to be limited by nutrition early in lactation. Since the rate of decline of the stage of lactation profile is similar regardless of production level, it is absolutely essential to obtain high summit milk yields in order to obtain high total lactation yields. Therefore, feeding balanced rations is needed for high production.

Dairy rations are balanced by calculating the amount of grain mix needed to supplement the requirements for energy, protein, calcium, and phosphorus which are not supplied by forages. It is not feasible to balance a ration for each cow in the herd, and it is not recommended to balance one ration for an entire herd. Instead, rations should be balanced for production groups in order to avoid underfeeding the high-producing cows and overfeeding the low producers.

The following procedures are suggested for balancing the ration for a herd split into two production groups with average body weights of 1,300 lb which are producing 60 lb of 3.5 percent milk fat and 40 lb of 4.0 percent milk fat. The calculations for balancing the ration for the higher producing group are shown in *Table 3*. Similar calculations would be made for the lower producing group.

■ **Step 1. Determining Nutrient Requirements.** Nutrient requirements are affected by (1) maintenance (body size), (2) milk and milk fat production, and (3) body weight gain. The nutrient allowance for pregnancy is not significant until the last two months of gestation when cows are normally dry.

When determining the requirements for milk production, always balance for a higher level of production than the group is averaging. If the herd is grouped by production, the level of production of the high group should be estimated about 15 pounds more than the

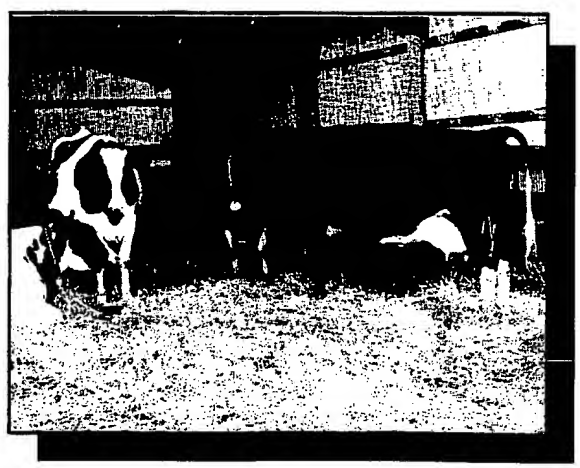

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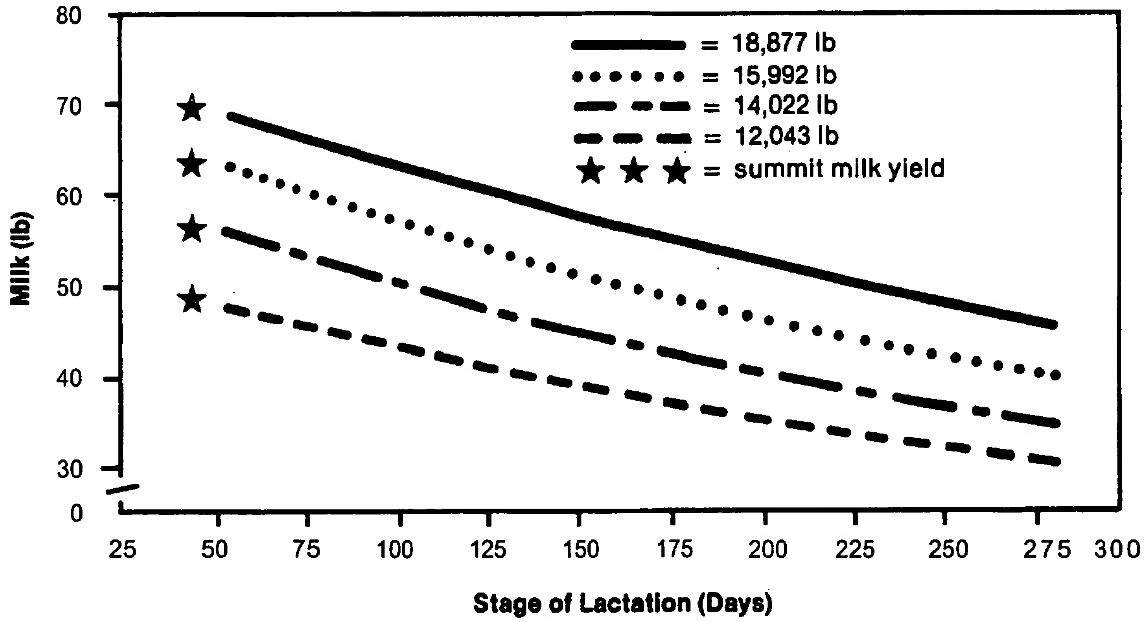
Figure 1. Comparison of Rolling Herd Average (RHA), summit milk yield, and stage of lactation profile of DHIA herds.



group average. The requirements for production should be about 5 pounds above average for the low-producing group. If the herd is not grouped, then the production requirements should be estimated at about 30 percent above the average production. Growth requirements can be estimated by increasing the nutrient allowances for maintenance by 20 percent for first lactation cows and 10 percent for second. A typical herd will need about 15 percent added to the maintenance allowance for growth.

Nutrient requirements for maintenance, maintenance plus pregnancy, milk production at various milk fat percentages and weight gain are shown in *Appendix Table 1.* To determine the requirement, select the maintenance requirement which corresponds to the average body size of the cows and the production requirement corresponding to the milk fat percentage of the group. The production requirement is then multiplied by the pounds of milk. In this example, the production requirements would be multiplied by 75 pounds (15 pounds above group average.)

■ **Step 2. Determining Forage Intake.** Dairy cows should be fed all the forage they will consume. However, there are limits as to how much forage dairy cows can eat. Normally, the maximum consumption of high quality forage dry matter will be about 2 1/2 percent of body weight when no grain is fed. Somewhat less consumption can be expected from lower quality forages. An average herd will consume about 1.8 percent of body weight as forage dry matter when enough grain is fed to meet requirements. When a herd is split, the high-producing cows will probably consume about 1.6 percent of their body weight as forage dry matter and the lower producing cows will consume about 2 percent of body weight. This means a group of high-producing cows weighing 1,300 pounds would eat 20.8 pounds of dry matter from forage while the lower producers would average 26 pounds.

■ **Step 3. Calculate Nutrients from Forages.** The values for energy, protein, calcium, and phosphorus are shown in *Appendix Table 2* on a dry matter basis. Calculate the nutrients supplied by the forages by multiplying the pounds of forage by the content of nutrients shown in the table, or better yet, from a forage analysis.

■ **Step 4. Determine Nutrients Required in Grain Mix.** Subtract the nutrients supplied by the forages (Step 3) from the nutrient requirements (Step 1).

■ **Step 5. Determine the Pounds of Grain Mix Needed.** Divide the energy required from the grain mix by its energy content. Most grain mixes will contain about 0.76 Mcal/lb of NEL on an as-fed basis.

■ **Step 6. Determine Protein Percentage of Grain Mix.** Divide the pounds of protein needed in the grain mix by the pounds of grain mix required.

■ **Step 7. Determine Calcium Percentage of Grain Mix.** Divide pounds of calcium required in grain mix by the pounds of grain mix required.

■ **Step 8. Determine Phosphorus Percentage of Grain Mix.** Divide pounds of phosphorus required in grain mix by the pounds of grain mix required.

Table 3. BALANCING DAIRY RATIONS. Group of 1,300 lb cows producing 75 lbs with 3.5% milk fat and consuming 10 lb average quality alfalfa hay and 36 lb of corn silage.

Step 1	**lbs**	**NEL (Mcal)**	**Protein (lbs)**	**Calcium (lbs)**	**Phosphorus (lbs)**
Maintenance*	1,300	11.04	1.47	0.061	0.043
Production	75(3.5%)	23.25	5.93	0.225	0.135
Weight Gain		2.32	0.32	—	—
Total Requirements		36.61	7.72	0.286	0.178

Step 2 and 3 Nutrients from Forages	**lb**	**lb D.M.**	**NEL (Mcal)**	**Protein (lb)**	**Calcium (lb)**	**Phosphorus (lb)**
Alfalfa	10.0	9.0	5.58	1.53	0,068**	0.021
Corn Silage	36.0	11.8	8.50	.94	0.032	0.024
Total	46.0	20.8	14.08	2.47	0.100	0.045
Average			0.68Mcal	1 1.9%	0.48%	0.21%

Step 4 (Step 1 -Step 3)				
Nutrients Required in Grain Mix	22.53Mcal NEL	5.25lb Protein	0.186lb Calcium	0.133lb Phosphorus

Step 5
Grain needed for Energy = 22.53 Mcal ÷ by 0.76 Mcal/lb = 29.6 lb grain

Step 6
Percent Protein Required in Grain = 5.25 lb ÷ by 29.6 lb X 100 = 17.7% protein

Step 7
Percent Calcium Required in Grain = 0.186 lb ÷ by 29.6 lb X 100 = 0.63% calcium

Step 8
Percent Phosphorus Required in Grain = 0.133 lb ÷ by 29.6 lb X 100 = 0.45% phosphorus

**The maintenance requirement has been increased by 15% for growth of young cows.*
***The calcium content of alfalfa has been reduced by 40% due to low availability.*

Ration Formulation

After determining the protein, calcium and phosphorus percentages needed *(Table 3)*, the grain mixture can be formulated by using Pearson's Square as follows:

Step 1. Write the desired percentage of the nutrient in the center of the square.

Step 2. Write the percentage of the nutrient in the grain and the supplement in the upper and lower left corners of the square respectively.

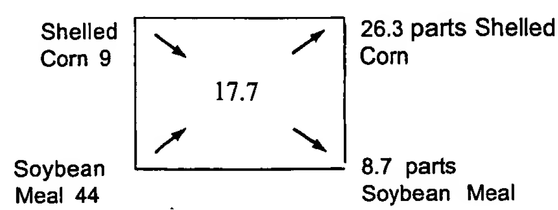
Step 3. Subtract diagonally across the square the smaller value from the larger and place the results at the right corner diagonally across from the left corner. The values at the upper right corner corresponds to the parts of the ingredient at the upper left corner and likewise for the lower figures. In the first examples, 26.3 parts of shelled corn and 8.7 parts of soybean meal will result in a mixture containing 17.7 percent protein.

Step 4. To convert to percentage, divide the parts of the ingredient by the total parts of both ingredients and multiply by 100.

Example: 8.7 ÷ (26.3 + 8.7) X 100 = 24.9% soybean meal.

Step 5. Multiply the percentage of the ingredient by the size of the batch to obtain the total pounds of that ingredient in the batch.
Example: 24.9% x 2,000 lb = 498 lb soybean meal.

Example Calculations
Protein percent = 17.7



Soybean meal = 8.7 ÷ (26.3 + 8.7) X 100 = 24.9% soybean meal

Calcium percent = 0.63

Grain Mix 0.03		22.37 parts Grain Mix
	0.63	
Dicalcium Phosphate 23		0.60 parts Dicalcium Phosphate

Dicalcium Phosphate % = .60 ÷ (22.37 + 0.60) X 100 = 2.6%
Dicalcium Phosphate

Phosphorus percent = 0.45

Grain Mix 0.30		17.55 parts Grain Mix
	0.45%	
Dicalcium Phosphate 18		0.15 parts Dicalcium Phosphate

Dicalcium Phosphate percent = 0.15 ÷ (17.55 + 0.15) X 100 = 0.8%

In this example, dicalcium phosphate would be added at the rate of 2.6 percent of the grain mix in order to meet the requirement for calcium. A less expensive ration could be formulated by adding 0.8 percent dicalcium phosphate for the phosphorus requirement and adding limestone for the remainder of the calcium supplement as follows:

2,000 X 0.8% dicalcium phosphate = 16 lb/ton

16 lb dicalcium phosphate X 23% calcium = 3.7 lb calcium supplied by dicalcium phosphate.

Calcium required = 52 lb dicalcium phosphate x 23% = 12.0 lb

Limestone required = (12.0 lb -3.7 lb) ÷ .38 = 23 lb limestone/ton.

A 2,000 lb batch of grain mix would include:

		percent
Shelled Corn	1,424lb	71.2
Soybean Meal	498 lb	24.9
Dicalcium Phosphate	16 lb	0.8
Limestone	22 lb	1.1
Sodium Bicarbonate *	30 lb	1.5
Trace Mineralized Salt **	10 lb	0.5
Vitamin A ***	4,000,000 units	2,000/lb
Vitamin D ****	2,000,000 units	1,000/lb

*Sodium Bicarbonate should be added to the grain mix at the rate of 1.5 percent when feeding more than 25 lb grain/cow daily.
**Trace mineralized salt is recommended for all grain mixes at 0.5 percent.
***Vitamin A is recommended at 4,000,000 units/ton.
****Vitamin D is recommended at 2,000,000 units/ton.

Balancing Total Mixed Rations

Similar procedures would be used as in the above example to formulate a total mixed ration (TMR). The rate of grain feeding was determined to be 29.6 pounds/day, so the amount of each ingredient would be determined by its percentage in the grain mix. The TMR for the above example would be as follows:

	Per Cow Daily
Alfalfa Hay	10.0 lb
Corn Silage	36.0 lb
Shelled Corn (29.6 X 71.2%)	21.1 lb
Soybean Meal (29.6 X 24.9%)	7.4 lb
Dicalcium Phosphate (29.6 X 0.8%) x 16	3.8 oz
Limestone (29.6 x 1.1%) X 16	5.2 oz
Sodium Bicarbonate (29.6 X 1.5%) x 16	7.1 oz
Trace Mineralized Salt (29.6 X 0.5%) X 16	2.4 oz
Vitamin A (29.6 X 2,000 U)	59,200 U
Vitamin D (29.6 X 1,000 U)	29,600 U

Another procedure for balancing a TMR is to formulate the TMR based upon the nutrient concentration required in the DM. *Appendix Table 2* shows the total dry matter intake (DMI) and forage DMI along with the nutrient concentrations required in the DM. The following steps are used to formulate a TMR for early lactation cows.

Step 1. Determine total and forage DMI. If the group average body weight is 1300 pounds, and the rate of total DMI and forage DMI is 3.8 and 1.5 percent *(Appendix Table 2)* respectively, then the cows would be expected to consume 49.4 pounds DM and 19.5 pounds forage DM. Therefore, the amount of grain mix DMI would be 29.9 pounds (49.4 lb -19.5 lb). If the grain mix contains 88 percent DM, then 34 pounds of grain mix would be needed (29.9 ÷ 0.88).

Step 2. Calculate nutrient content of forages.

	lb	DM lb	NEL Mcal	Protein lb	Calcium lb	Phosphorus lb
Alfalfa Hay	10	9.0	5.58	1.53	0.068	0.021
Corn Silage	30	10.5	7.56	.84	0.028	0.021
Total	40	19.5	13.14	2.37	0.096	0.042
Average		48.8%	0.67	12.2%	0.49%	0.22%

Step 3. Calculate nutrients required in grain mix.

A. Total Protein (lb) = Total lb DM X % Protein Required = 49.4 lb DM X 18% Protein = 8.89 lb Protein

B. Grain Mix Protein (lb) = Total Protein - Forage Protein = 8.89 lb -2.37 = 6.52 lb Protein

C. Grain Mix Protein (%) = (6.52 lb ÷ 34 lb) X 100 = 19.2% Protein

D. Total Calcium (lb) = Total DM X % Calcium Required = 49.4 lb X 0.70% = 0.346 lb Calcium

E. Grain Mix Calcium (lb) = Total Calcium - Forage Calcium = 0.346 - 0.096 = 0.25 lb Calcium

F. Grain Mix Calcium (%) = (0.25 lb ÷ 34 lb) X 100 = 0.74% Calcium

G. Total Phosphorus (lb) = Total DM X % Phosphorus Required = 49.4 X 0.45% = 0.222 lb Phosphorus

H. Grain Mix Phosphorus (lb) = Total Phosphorus - Forage Phosphorus = 0.222 lb - 0.042 lb = 0.018 lb Phosphorus

1. Grain Mix Phosphorus (%) = (0.18 lb ÷ 34 lb) X 100 = 0.53% Phosphorus

Step 4. Determine amounts of supplement and grain required using Pearson's Square.

Shelled Corn 9 ↘ ↗ 24.8 parts Shelled Corn

19.2
Protein

Soybean Meal 44 ↗ ↘ 10.2 parts Soybean Meal

Soybean Meal % = 10.2 ÷ (10.2 + 24.8) X 100 = 29.1%

Shelled Corn 0.03 ↘ ↗ 22.26 parts Grain Mix

0.74
Calcium

Dicalcium Phosphate 23 ↗ ↘ 0.71 parts Dicalcium Phosphate

Dicalcium Phosphate % = 0.71 ÷ (22.26 + 0.71) X 100 = 3.1% Dicalcium Phosphate

Shelled Corn 0.30	0.53 Phosphorus	17.47 parts Grain mix
Dicalcium Phosphate 18		0.23 parts Dicalcium phosphate

Dicalcium Phosphate % = 0.23 ÷ (17.47 + 0.23) X 100 = 1.3%
Dicalcium Phosphate

Step 5. Grain mix formulation

	Pounds	%	Per Cow Daily
Shelled Corn	1,316	65.8	22.4 lbs.
Soybean Meal	582	29.1	9.9 lbs.
Dicalcium Phosphate	62	3.1	16.0 oz.
Sodium Bicarbonate	30	1.5	8.0 oz.
Trace Mineralized Salt	10	0.5	2.7 oz.
Vitamin A (IU)	4,300,000		73,100 IU
Vitamin D (IU)	1,400,000		23,800 IU
Vitamin E (IU)	20,750		352 IU

Managing Feeding Programs

Cows should be fed and managed according to the production cycle—early, mid, and late lactation and two stages of the dry period. The nutritient requirements are shown in Appendix Table 2.

1. Early lactation
   - A. Cows should be fed for production.
   - B. Cows should be challenged with a high energy ration soon after calving. Waiting longer than a few days may cause digestive upsets.
   - C. Feed additional protein *(Appendix Table 2)* to stimulate summit milk yield.
   - D. Fresh cows should be milked out completely.
2. Mid lactation
   - A. Cows should be fed **according** to production.
   - B. Cows should be gaining weight and bred by this time.
3. Late lactation
   - A. Cows should be fed **according** to body condition.
   - B. Cows should gain enough body condition to be well covered with fat at dry-off.
4. Dry period
   - A. Cows should be fed **according** to body condition.
   - B. Cows should be well covered with fat without developing fat pads over the pin bones.
   - C. Thin cows should be fed additional grain mix (up to one percent of body weight).
   - D. Grass hay or pasture is the preferred forage.
5. Prepartum period
   - A. Cows should be **adjusted** to the lactating ration two weeks before calving *(Appendix Table 2).*
   - B. If the lactating cows are fed silage, include silage in the ration.
   - C. Prepartum milking is recommended when excessive udder edema or mastitis develops.

Nutritional and Metabolic Disorders

DESCRIPTION	PREVENTION
Acidosis (Indigestion, founder)	
Lactic acid is produced in the rumen at accelerated rates as the pH drops when highly fermentable carbohydrates are fed. Cows go off feed, may kick at their belly and may exhibit varying degrees of diarrhea.	Avoid sudden changes to high levels of grain feeding. Include 1½% sodium bicarbonate in grain mix when feeding more than 25 lb/cow/day.
Bloat	
Frothy-type gases accumulate in the rumen and cause distention of the abdominal cavity, especially on the left side. Breathing becomes labored and death may result from suffocation due to crowding of the heart and lungs.	Feed bloat preventing drugs when pasturing legumes.
Displaced Abomasum	
The abomasum shifts positions and may twist which prevents passage of digesta. Usually occurs in recently fresh cows fed large amounts of corn silage during the dry period or large amounts of grain and ensiled forages after freshening.	Feed long, dry grass hay during dry period. Include at least 5 lb dry forage after freshening and avoid finely chopped forages.
Fat Cow Syndrome	
Cows over-conditioned when dry tend to have enlarged, fatty livers. Soon after calving, such symptoms as loss of appetite, retained placenta, milk fever, displaced abomasum, and ketosis may occur.	Feed balanced ration during dry period. Dry grass hay is preferred to ensiled feeds, especially corn silage, and avoid fattening during the dry period.
Grass Tetany	
Associated with pasturing lush grass or cereal crop pastures, Animals become nervous, lose control of their limbs, exhibit convulsions, and may die. Sometimes confused with milk fever in lactating cows on magnesium deficient rations.	Supplement 2 oz of magnesium oxide daily to grazing cattle on lush pastures. Include 0.5% magnesium oxide in grain mixes in problem herds.
Hardware Disease	
Occurs when sharp pieces of metal puncture the reticulum. Animals lose appetite, become gaunt, are reluctant to walk, and develop a fever.	Avoid making hay or silage from fields where wire has been discarded. Give magnets to cows in problem herds.
Ketosis	
Usually occurs during the first 6 to 8 weeks of lactation when body weight loss is greatest, especially in herds with restricted grain consumption. May occur anytime when appetite is depressed. Breath of affected cows smells like acetone.	Avoid over-conditioned dry cows. Lead feed last 2 to 3 weeks of dry period. Increase grain consumption with buffers early in lactation to reduce weight loss. Treat with propylene glycol or sodium propionate.

Nutritional and Metabolic Disorders

DESCRIPTION	PREVENTION
Low Fat Test	
Associated with restricted forage consumption due to high grain intake, forages chopped or ground to fine, or pelleted feeds.	Avoid finely ground or chopped forages, encourage forage consumption by feeding more times/day, add 1½% sodium bicarbonate plus 3/4% magnesium oxide to grain mix.
Milk Fever	
Usually occurs just prior to or shortly after calving, but can occur later in lactation. Caused by low blood calcium. Early symptoms include quivering of muscles then staggering, then the cow goes down and usually turns head toward flank. Delayed treatment can result in death.	Restrict alfalfa intake to 5 lb or less during dry period. Grass hay is preferred. Calcium deficient rations can be fed last one or two weeks before calving.
Nitrate Poisoning	
Excessive nitrate intake results in restricted oxygen-carrying capacity of the hemoglobin due to the conversion of nitrate to nitrite. Symptoms include labored breathing, brownish-colored blood, occasional abortions, depression, and death in severe cases.	Stressed crops due to drought or frost may accumulate nitrate. Levels above 5,000 ppm KNO_3, 3,000 ppm NO_3, or 1,500 ppm Nitrate N are dangerous. Test forages if nitrate problems are suspected.
Prussic Acid Poisoning	
Drought or frost-stressed sorghum crops are the most dangerous, especially when grazed. Symptoms include labored breathing, depression, staggering, convulsions and death. Blood remains bright red.	Avoid grazing susceptible crops. Making silage or hay usually minimizes risk.

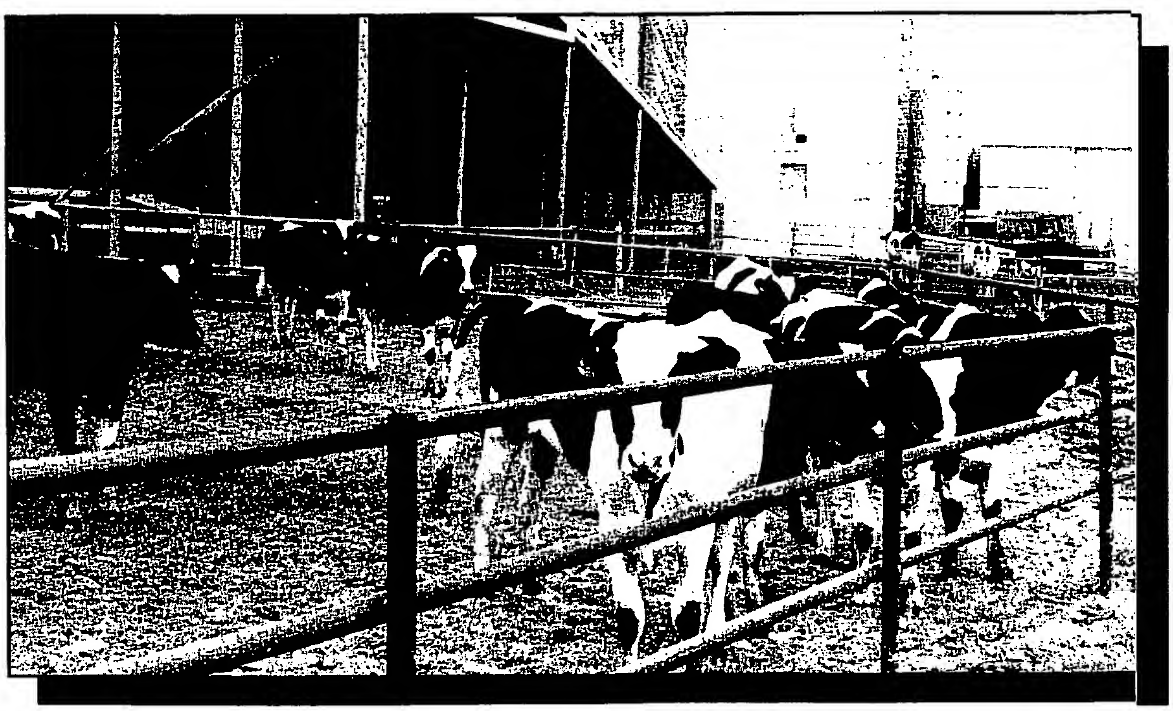
APPENDIX TABLE 1. Daily Nutrients Requirements of Dairy Cows (NCR–1988).

Body Weight lb	Protein lb	NEL Mcal.	Calcium lb	Phosphorus lb	Vitamin A 1,000 IU	Vitamin D 1,000 IU
Maintenance Mature Lactating Cows*						
700	0.67	6.02	0.028	0.020	24	10
800	0.77	6.65	0.032	0.023	28	11
900	0.88	7.27	0.036	0.026	31	12
1,000	0.92	7.86	0.041	0.029	34	14
1,100	1.08	8.45	0.045	0.031	38	15
1,200	1.18	9.02	0.049	0.034	41	16
1,300	1.28	9.57	0.053	0.037	45	18
1,400	1.37	10.12	0.057	0.040	48	19
1,500	1.46	10.66	0.061	0.043	52	20
1,600	1.55	11.19	0.065	0.046	55	22
1,700	1.64	11.71	0.069	0.049	59	23
Maintenance Plus Last 2 Months Gestation of Mature Dry Cows						
700	1.39	7.82	0.046	0.028	24	10
800	1.46	8.65	0.053	0.032	28	11
900	1.54	9.45	0.059	0.036	31	12
1,000	1.61	10.22	0.066	0.040	34	14
1,100	1.75	10.98	0.072	0.044	38	15
1,200	1.90	11.72	0.079	0.048	41	16
1,300	2.03	12.45	0.086	0.052	45	18
1,400	2.17	13.16	0.092	0.056	48	19
1,500	2.31	13.86	0.099	0.060	52	20
1,600	2.44	14.54	0.105	0.064	55	22
1,700	2.57	15.22	0.112	0.068	59	23
Milk Production— Nutrients Per Pound of Milk of Different Milk Fat Percentages						
Milk Fat %						
2.5	0.072	0.27	0.0024	0.0017	—	—
3.0	0.073	0.29	0.0027	0.0017	—	—
3.5	0.079	0.31	0.0030	0.0018	—	—
4.0	0.086	0.33	0.0032	0.0020	—	—
4.5	0.092	0.36	0.0035	0.0021	—	—
5.0	0.100	0.38	0.0037	0.0023	—	—
5.5	0.105	0.40	0.0039	0.0024	—	—
6.0	0.108	0.42	0.0041	0.0026	—	—
Weight Gain—Nutrients Required to Re-gain Body Weight Loss						
	0.32	2.32				

*To allow for growth of young lactating cows, increase the maintenance allowances for all nutrients except vitamins A and D by 20 percent during the first lactation and 10 percent during the second lactation.

APPENDIX TABLE 2. Recommended Nutrient Content of Ration Dry Matter for Dairy Cows (NCR—1988).

	Early Lactation	Mid Lactation	Late Lactation	Dry Period 1st 6wk	Dry Period Last 2wk
DMI, % Body Weight	3.8	3.4	3.0	2.0	2.2
Forage DMI, % Body Weight	1.5	1.7	2.0	1.6	1.6
NEL, Mcal/lb	0.76	0.73	0.70	0.57	0.65
Protein					
CP%	18	16	14	12	14
UIP%	6.3	5.7	5.0		
DIP%	10.4	9.7	8.4		
Fiber (minimum)					
CF,%	12	15	18	22	20
ADF,%	15	18	21	25	23
NDF,%	27	33	39	45	40
Minerals (minimum)					
Ca,%	0.70	0.60	0.55	0.40	0.40
P,%	0.45	0.40	0.36	0.25	0.25
Mg,%	0.25	0.20	0.20	0.16	0.16
K,%	1.00	0.90	0.90	0.65	0.65
Trace Mineral Salt	0.25	0.25	0.25	0.25	0.25
Buffer	0.75	0.75			
Vitamins					
A,IU/lb	1,450	1,450	1,450	1,800	1,800
D,IU/lb	450	450	450	540	540
E,IU/lb	7	7	7	7	7



APPENDIX TABLE 3. Nutrient Content of Common Feeds.

	Crude Protein %	UIP %	NEL Mcal/lb	Crude Fiber %	ADF %	NDF %	Calcium %	Phosphorus %
FORAGES	----------------------	----------	----100%	Dry	Matter----	----------	----------	----------
Alfalfa								
Bud	20.0	28.0	0.60	24.0	29.0	40.0	1.35	0.30
1/10 Bloom	17.0	28.0	0.58	26.0	31.0	42.0	1.25	0.25
1/2 Bloom	16.0	28.0	0.56	28.0	33.0	46.0	1.25	0.25
Full Bloom	14.0	28.0	0.54	30.0	35.0	50.0	1.25	0.25
Barley								
Boot	13.0	27.0	0.58	27.0	31.0		0.25	0.30
Bloom	9.8	27.0	0.55	30.0	40.0		0.22	0.30
Dough	9.8	27.0	0.54	33.0	38.0		0.21	0.26
Brome								
Boot	12.0	44.0	0.56	30.0	35.0	65.0	0.32	0.37
Bloom	10.0	44.0	0.51	37.0	43.0	68.0	0.30	0.35
Mature	8.0	44.0	0.46	42.0	51.0	70.0	0.28	0.33
Clover, Red								
Early Bloom	16.0	31.0	0.56	26.1	35.0	43.0	1.53	0.27
Full Bloom	14.6	31.0	0.50	28.8	36.0	46.0	1.31	0.25
Clover, Sweet								
Early Bloom	15.0		0.50	33.4	40.0		1.30	0.20
Full Bloom	11.0		0.43	41.9	51.2		1.25	0.17
Corn Silage								
Well-Eared	8.4	31.0	0.72	23.7	28.0	51.0	0.27	0.22
Few Ears	8.1	31.0	0.64	32.3	30.0	53.0	0.34	0.19
Fescue								
Boot	10.5		0.55	33.0	43.0	63.0	0.60	0.40
Bloom	8.5		0.51	42.0	51.3	67.0	0.50	0.40
Mature	6.0		0.47	46.0	56.7	70.0	0.48	0.35
Milo Silage								
Dough	8.3		0.60	26.0	33.0	45.0	0.32	0.18
Oats								
Boot	13.0		0.58	29.0	35.0	58.0	0.25	0.30
Bloom	9.8		0.55	32.0	39.0	62.0	0.22	0.30
Dough	8.0		0.54	27.0	34.0	56.0	0.21	0.30
Prairie								
Early	10.0		0.48	38.8	47.1		0.32	0.07
Late	7.0		0.40	46.6	57.5		0.29	0.07

APPENDIX 3 CONTINUED. Nutrient Content of Common Feeds.

	Crude Protein %	UIP %	NEL Mcal/lb	Crude Fiber %	ADF %	NDF %	Calcium %	Phosphorus %
Rye								
Boot	12.8		0.58	34.0	40.7		0.39	0.32
Bloom	9.0		0.54	38.9	47.2		0.35	0.32
Dough	7.0		0.50	36.0	46.0		0.32	0.32
Sorghum Silage								
Milk	7.5		0.56	28.5	33.3		0.35	0.20
Dough	7.0		0.58	27.0	31.3		0.30	0.22
Sorghum-Sudan								
Immature	13.0		0.57	30.0	40.0	65.0	0.43	0.36
Headed	8.0		0.48	36.0	42.0	68.0	0.55	0.30
Soybeans								
Bloom	17.0		0.54	29.8	40.0		1.26	0.27
Dough	16.8		0.63	28.5	39.0		1.29	0.33
Sunflowers								
Bloom	11.0		0.63	33.5	42.0	45.0	0.80	0.30
Triticale								
Boot	13.5		0.58	28.0	34.0		0.25	0.30
Bloom	10.0		0.55	32.0	38.0		0.22	0.30
Dough	8.0		0.54	30.0	36.0		0.21	0.30
Wheat								
Boot	13.0		0.58	29.0	34.0		0.27	0.27
Bloom	10.3		0.55	32.0	38.0		0.26	0.27
Dough	8.0		0.54	28.0	36.0		0.25	0.27

APPENDIX 3 CONTINUED. Nutrient Content of Common Feeds.

	Crude Protein %	UIP %	NEL Mcal/lb	Crude Fiber %	ADF %	NDF %	Calcium %	Phosphorus %
GRAINS, BYPRODUCTS & PROTEIN SUPPLEMENTS								
Barley	13.5	27.0	0.88	5.7	7.0	19.0	0.05	0.38
Beef Pulp	9.7	45.0	0.81	19.8	33.0	54.0	0.69	0.10
Brewers Grains	25.4	49.0	0.68	14.9	24.0	46.0	0.33	0.55
Corn, Shelled	10.0	52.0	0.92	2.6	3.0	9.0	0.03	0.29
Corn & Cob Meal	9.0		0.87	9.4	11.0	28.0	0.07	0.27
Corn Distillers Grains	23.0	54.0	0.90	12.1	17.04	3.0	0.11	0.43
Corn Gluten Feed	25.6	25.0	0.87	9.7	12.0	45.0	0.36	0.82
Corn Gluten Meal	67.2	55.0	0.94	4.8	9.0	37.0	0.16	0.50
Corn Hominy Feed	11.5		0.91	6.7	13.0	55.0	0.05	0.57
Cottonseed Meal	44.3	43.0	0.81	12.8	20.0	28.0	0.21	1.16
Cottonseed Hulls	4.1		0.45	47.8	73.0	90.0	0.15	0.09
Cottonseed, Whole	23.0		1.01	24.0	34.0	44.0	0.21	0.64
Fat, Animal			2.65					
Linseed Meal	38.3	35.0	0.81	10.1	19.1	25.0	0.43	0.89
Milo	9.7	54.0	0.84	2.0	9.0	18.0	0.04	0.34
Milo Head Chop	9.0		0.75	13.0			0.16	0.29
Molasses	5.8		0.75				1.00	0.11
Oats	13.3	17.0	0.80	12.1	16.0	32.0	0.07	0.38
Rye	13.8	19.0	0.88	2.5			0.07	0.37
Soybeans	42.8	26.0	0.96	5.8	10.0		0.27	0.65
Soybean Meal, Expeller	47.7	35.0	0.89	6.6			0.29	0.68
Soybean Meal, Solvent	49.9	35.0	0.88	7.0	10.0		0.30	0.68
Soybean Meal, De-hulled	55.1	35.0	0.91	3.7	6.0	8.0	0.29	0.70
Soy **Hulls**	12.1		0.80	40.1	50.0	67.0	0.49	0.21
Sunflower Meal	49.8	26.0	0.67	12.2			0.44	0.98
Wheat, Hard	14.4	22.0	0.93	2.8	4.0		0.05	0.43
Wheat, Soft	13.0	22.0	0.94	2.4			0.05	0.43
Wheat, Bran	17.1	29.0	0.73	11.3	15.0	51.0	0.13	1.38
Wheat, Mids	18.4	21.0	0.71	8.2	10.0	37.0	0.13	0.99
CALCIUM AND PHOSPHORUS SUPPLEMENTS								
Bone Meal	13.2						30.17	12.86
Dicalcium Phosphate							23.00	19.30
Limestone							39.39	
Monocalcium Phosphate							16.40	21.60
Monosodium Phosphate								22.50

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MF-754 (Revised) January 1989

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4-85—4M; 1-89—4M; 4-95—3M